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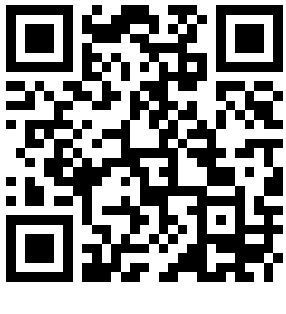

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COMPANIES' MEETINGS, REPORTS, DIVIDENDS, STATUTORY RETURNS, &c—

(Abbreviations:—Mtg., Meetings of Shareholders; Rpt., Reports of Directors; Div., Dividend; Rev., Revenue; Stat., Statutory Returns.)

Akester Electric Motor Company—374; Stat., 427, 453.
Alcock Electric Light and Motive Power Company—Mtg., 232.
Aluminium Company—511.
American Bell Telephone Company—175.
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Anglo-Portuguese Telephone Company—233; Rpt., 147; Mtg., 174.
Aurora Electric Lighting and Distribution Company—Stat., 703.
Automatic Electric Railway Signal Company—Mtg., 373.
Babcock and Wilcox—4; Mtg., 729.
Bath Electric Lighting and Engineering Company—Mtg., 511.
Bedford Electric Light Company—Mtg, 55.
Birmingham Electric Supply Company—116; Stat., 401.
Bournemouth and District Electric Light Supply Company—259, 453; Stat., 703.
Boy Messengers and Electric Call Company—59, 511.
Brazilian Submarine Telegraph Company—Mtg, 25, 702; Div., 147, 649; Rev., 29, 59, 89, 117, 147, 175, 205, 233, 259, 287, 317, 348, 421, 428, 454, 482, 512, 540, 568, 596, 621, 649, 677, 703; Rpt., 676.
British Electro-Chemical Agency—481.
British Insulated Wire Company—175.
Brockley Electric Lighting and Manufacturing Company—Stat., 373.
Brush Electrical Engineering Company—Rpt., 567; Mtg., 619.
Byng Telephone Company—453, 648.
Caledonian Telephone Company—205.
Callender's Bitumen Telegraph and Waterproof Company—Div., 621.
Caustic Soda Syndicate—Mtg, 204.
Cawthra (J.) and Company—Stat., 595.
Chelsea Electricity Supply Company—Mtg., 54.
Chili Telephone Company—Rpt., 286; Mtg, 316; Stat, 427.
China and Japan Telephone Company—Mtg., 175.
City of London Electric Lighting Company—317, 649; Mtg, 650.
City of London Electric Lighting (Pioneer) Company—596, 729; Stat., 373; Mtg., 116, 618, 649, 703.
City and South London Railway—Rev., 29, 59, 89, 117, 147, 175, 205, 233, 259, 287, 317, 348, 374, 401, 428, 512, 540, 568, 596, 622, 649, 677, 703, 729; Mtg., 203, 259, 423, 454, 482; Rpt., 400.
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Edison and Swan United Electric Light Company—Rpt., 317; Mtg., 287, 345; Stat., 453.
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NOTES.

Electrical science was well represented at the conversazione of the Royal Society on Wednesday evening, both as regards the guests and the exhibits. Mr. Wimshurst showed his very interesting alternating influence machine. Our readers need not be alarmed at the immediate development of a new and complicated branch of electrical science, such as that which has grown round the alternating dynamo. The machine, which has many points of theoretical interest, performs one experiment. It will not charge a Leyden jar. Mr. Gordon had erected the Tomlinson sub-station regulator which was recently shown at the Institution of Civil Engineers. It looks like a cross between a guillotine and a railway signal-box, and is intended to control transformers of an output of 1,000 H.P. Mr. Gordon has published some very striking figures as to the economy of the system, but these must be studied with care before any opinion can be formed as to the value of the very ingenious mechanism.

Dr. Oliver Lodge exhibited a high-speed revolving mirror for analysing sparks, and two clocks for continually pointing out the direction of the earth's orbital motion, so that at any moment it can be seen in which direction we are rushing through the ether. He also showed two gallon Leyden jars, with independent circuits, one having an adjustable self-induction, consisting of two straight wires with a sliding cross-piece. The circuits could thus be tuned to resonance, and on the discharge of one the other resounds and overflows. Mr. Shelford Bidwell showed his interesting adaptations of selenium cells, Prof. Crookes his phosphorescing gems; and some forms of Clark cells, provided with valves and stirrers, were exhibited by Prof. Schuster.

In another column we describe two new methods of measuring self-induction, reproduced from an article by Prof. Anderson, in the *Philosophical Magazine*. The methods show a great deal of ingenuity, and the later one seems to possess considerable merit from a practical point of view. The first method does not appear as if it would prove useful. A complicated key is required, and the formula can only be applied when the resistance of the galvanometer is known. As galvanometer coils are wound with copper wire, whose temperature is always uncertain, this defect is a serious one. A further disadvantage is caused by the fact that the formula involves the product of the sines of two angular deflections, and this is not readily obtained from the readings of the instrument, although the ratio of the two could be found with ease. The other method is much simpler, and consists of a modification of one of Maxwell's condenser methods. It can be applied to any Wheatstone bridge, and has the additional advantage of being a null method. We think the merits of null methods are frequently over-estimated. It is no doubt true that with such methods a very sensitive instrument can be used, and all error due to uncertainty of the calibration of the galvanometer is eliminated; but in practice these advantages are valueless, because the sensitive instrument is not generally at disposal, and the connection between the deflection and the current is known quite as accurately as is necessary when the other sources of experimental error are considered. Null methods are always slower and more troublesome than deflectional methods, and, as a rule, it is quicker and more accurate to take the mean of several observations by the latter, than one observation by the former. The difference between them is something like that distinguishing a Siemens dynamometer from a direct reading deflectional instrument. Although for some purposes the former must be used, the advantages it possesses are, as a rule, more than counterbalanced by the quickness and convenience of the latter.

In *The Electrician* for April 24 we alluded to a method, suggested by M. Boucherot, for obtaining a constant current supply of electrical power from a pair of mains kept at constant potential. The device consisted a new kind of transformer formed by combining an inductive coil with a condenser, and, in two further numbers of our contemporary, *L'Electricien*, M. Boucherot enters with great elaboration into the various modifications which can be made in this new type of converter. He shows that the constant current circuit need not necessarily be non-inductive, and may consist of the primary coil of a transformer; and he pictures an installation in which a constant potential dynamo supplies a pair of mains which are tapped at places by transformers of the ordinary type for constant potential circuits, and at others by transformers of the new type for constant-current distribution. He also claims to have been so far successful with a particular converter, supplied with a constant potential of 800 volts, as to obtain from it a constant current of one-third of an ampere at potentials varying between 100 and 1,000 volts. While he may be congratulated on this success, his bare statement that the new transformers will only cost as much as those of the ordinary type for the same output at once challenges contradiction.

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Condensers of from 100 microfarads cannot be obtained at such a moderate price as M. BOUCHEROT appears to think, nor are there any condensers yet in the market which can be guaranteed to stand the potentials to which they would have to be subjected in practice.

THE examination question, alluded to by a correspondent, in which an explanation is asked of the terms series-multiple, multiple-series, series-parallel, and parallel-series, is a monstrous one. Our correspondent is quite justified in thinking that they are vague. He asks, "Could not the word arc be entirely abolished, and for multiple substitute parallel?" and adds, "Why do not electricians confine themselves simply to the terms series and parallel?" To this we reply that these senseless terms have long ago been abolished, and electricians *do* confine themselves simply to the terms series and parallel. We are surprised to learn that such expressions still linger in the lecture rooms.

WE beg to decline to adjudicate on the application of these ill-devised terms to the illustrations from Mr. URQUHART'S book. Engineers would describe the first arrangement as consisting of various groups of lamps in series (or series groups of lamps), on 200-volt mains, and the second as various parallel groups of lamps on a series circuit. These systems are so rarely used that the ingenuity of the word-coiner is not required. We should like to see four or five-candle lamps more generally used for domestic lighting. It is impossible to make a practical 100-volt four-candle lamp, and it would be, therefore, necessary to wire them in series; but it would assuredly be unnecessary to give this method of wiring any of the clumsy names alluded to by our correspondent.

Finsbury Technical College.—The students of this College will hold a conversazione on Friday evening next, at 7.30 p.m.

Electric Traction at Florence. — The Florence-Fiesole line has been reopened, the cars being fitted with a new style of electric brake.

Lyons.—According to the *Bulletin International de l'Electricité*, the First of May "manifestants" managed to cut some 600 underground telephone wires.

Electric Alarms in Mexico.—Some 20 electric fire alarms are to be set up in the City of Mexico. These are of various makes, and the best will be ultimately selected.

The St. James and Pall Mall Company.—The current sold by this Company for the quarter ending March 31, 1891, brought in £9,652, as against £1,818 for the corresponding period last year.

Accumulator Traction.—According to the *Elektrotechnischer Anzeiger* experiments in traction have been carried on for some time by Messrs. Siemens and Halske on the Lichterfelde-Teltow line, Tudor accumulators being used.

Crystal Palace Electrical Exhibition.—This Exhibition will be opened in November next, and will be continued for some months. No charge will be made for space. For further particulars see our advertisement columns.

The Barking-road Cars.—It is stated that the contract for the accumulator cars on the Barking-road line has been renewed with the General Electric Power and Traction Company at an extra penny per car mile—that is, at 5½d. per car mile.

The Government and the Telephones in Italy.—The proposed law for the acquisition of the Italian telephone system will shortly be laid before Parliament, and it is to be hoped that it will pass both Chambers before the end of June.

Standards of Illumination.—The figure accepted abroad as the ratio between a Hefner-Alteneck amylacetate standard lamp and the English standard candle is, that one Hefner-Alteneck lamp = 8·186 English candle.

Personal.—Mr. Percy E. Scrutton informs us that he is no longer connected with the Electrical Engineering Corporation, and has accepted the post of manager of a London branch recently opened by Mr. L. C. Howell, of Llanelly, at 24, Queen Victoria-street, E.C

Clerk-Maxwell Scholarship.—The Clerk-Maxwell scholarship for the advancement by original research at the Cavendish laboratory of experimental physics, especially of electricity, magnetism, and heat, has been awarded to William Cassie, M.A., of Trinity College.

Christiania.—Some £25,000 have been voted for building a central lighting station at Christiania according to the plans of Herr Knud Bryn. Tenders will be shortly invited for executing the work, which will be carried out on the three-wire system, and will be capable of supplying 4,000 16 c.p. lamps.

Copper.—Messrs. Merton's annual statistics of the copper production of the world show that the output of 1890 reaches the highest figures yet attained. The production of the United States has more than doubled since 1883, and last year's outturn was upwards of five times that of 1879.

The Junior Engineering Society.—On Saturday afternoon last a large party of members of this Society visited the Tower Bridge Works. They were received and shown over by Mr. E. W. Cruttwell, the resident engineer, who afforded every facility for a complete inspection of the bridge so far as it has advanced, and explained its construction and erection.

The Anglo-American Telegraph Company.—This Company notifies having opened a cable office in Montreal, which is in direct communication by special wires with their cable station in Newfoundland, thus giving the cabling public every facility for speedy transmission of messages. The entire route from Glasgow to Montreal is under their independent control.

Cable Extensions.—We understand that negotiations are proceeding between the Imperial Government and the Eastern and South African Telegraph Company for laying a cable from Zanzibar to Mauritius, *viâ* the Seychelles. The French Government are also considering the question of connecting the Island of Réunion with Mauritius in the event of the cable being extended to the latter place.

Electrical Standards Committee.—A meeting of the Electrical Standards Committee was held on Monday at the Board of Trade. The following members were present:—Sir W. Thomson, Lord Rayleigh, Prof. Carey Foster, Mr. Glazebrook, Dr. John Hopkinson, Mr. Preece, Mr. Graves, Major Cardew, and Mr. Courtenay Boyle. Prof. Silvanus Thompson attended, and gave evidence on behalf of the London County Council.

Munich.—Herr O. Von Miller has laid before the Munich Town Council a project for the electric lighting of the town. It is proposed to derive 2,200 H.P. for the purpose from turbines driven by water from the Isar. The number of lamps is to be 9,500, and the capital required is estimated at £155,000. The annual cost of running is put at £30,000, and a surplus of £10,000 is worked out. At this rate electricity will cost only two-fifths the price of gas.

The Coffin Welding Process.—Experiments are being made with this continuous current welding process, which is being put forward as an improvement on the alternating current method. We are informed that a 1 inch bar can be welded with the current direct from a dynamo with a 1 h.p. engine. It is claimed that this process can utilise the current supplied from central stations, and, dispensing, as it does, with transformers, will enable electrical welding to be adopted by a large number of metal workers.

The Decimal Association.—A joint deputation from the Associated Chambers of Commerce and the Decimal Association will be received to-day by Mr. Goschen and Sir Michael Hicks-Beach to urge the Government to take the necessary steps for rendering compulsory the adoption of the metric system of weights and measures, as the first stage in the introduction of a complete decimal system. The Decimal Associa-

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tion will present a petition praying for the appointment of a Royal Commission or Select Committee.

Berwick-upon-Tweed.—The Lighting Committee of the Urban Sanitary Authority have reported that they have fully gone into the matter of lighting the town. Finding that the gas company were not disposed to meet them either in price or quality of the gas, they directed their attention to the electric light. The result is that one firm of electrical engineers has offered to undertake to erect, work, and maintain an electric light installation for a period of five years, the proposed installation to consist of 21 arc lamps of 2,000 c.p. nominal, and 20 20 c.p. incandescent lamps.

The Telephone and the Telegraph in Paris.—In November last the French Postal Telegraph Department inaugurated experimentally a service of "telephonic messages." This new service allowed the public to telephone a telegram from any telegraph office provided with telephonic apparatus to any of the ten chief telegraph offices in Paris. This service has been so much appreciated that the area served by it is to be extended and the system definitely adopted. Moreover, exchange subscribers are to be allowed to send "telephonic telegrams" from their own houses, at the rate of 50 centimes per five minutes' conversation.

Electrical Patents.—Referring to the proposed celebration on the 25th of this month of the centenary of the French Patent Office system, *La Lumière Electrique* remarks on the extreme rarity of electrical patents previous to and for long after 1791. In France, in 1809, a patent was taken out for lighting ships' compasses, and in 1819 a doctor patented an electrical machine. In England a patent was taken out in 1766 for a marine compass. In 1782 an electrical machine for giving positive and negative electricity, and in 1792 a magnetic ore separator were patented. In America no electrical patents were heard of until the beginning of the present century.

Royal Institution.—The annual meeting of the Royal Institution was held on Friday last. The real and funded property of this Institution now amounts to above £83,000, entirely derived from the contributions and donations of the members. Fifty-six new members were elected in 1890, and 63 lectures and 19 evening discourses were delivered. The books and pamphlets presented amounted to about 285 volumes, making, with 561 volumes (including periodicals bound) purchased by the managers, a total of 846 volumes added to the library in the year. The following gentlemen were unanimously elected as officers for the ensuing year:—President, the Duke of Northumberland; treasurer, Sir James Crichton Browne; secretary, Sir Frederick Bramwell.

Bath.—At the fortnightly meeting of the Surveying Committee, held on Monday, the report of the Electric Lighting Committee on Prof. Forbes' report was considered. The Committee asked the Authority to retain a competent electrical engineer to make periodical visits in order to test the conditions of the circuits, to examine the street lighting, and to note the constancy of the electric pressure of the incandescent lamps; and to authorise them to supply a few additional arc lamps to those parts where the lights are now too far apart. The Electric Committee believed that not more than 12 lamps would be required to greatly improve the street lighting. Mr. Massingham was present, and in answer to questions stated that the frosted globes took off from the light 30 or 40 per cent., but they distributed the light better. The report was adopted.

The Endowment of Research.—At the last meeting of the Académie des Sciences it was announced that the late M. Cahours had left the Académie the sum of 100,000fr., the annual interest from which was to be devoted to aid necessitous science students in completing any valuable scientific research they might be engaged in, chemical research to be especially considered, the premiums to cease as soon as the holders of them have obtained well-remunerated posts. M. Janssen, alluding to M. Cahours' bequest, remarked that the gift was not only important in amount, but as marking a new departure in the form of awards at the disposal of the Académie. The usual prizes of the Académie were beyond the reach of beginners, and yet amongst these how much talent was there not, which, properly cultivated, would prove a gain and an honour to science.

Austrian Telephonic Statistics.—At the end of 1889 the State possessed telephonic exchanges in 28 towns, to which the total number of subscribers was 664, or less than 24 per exchange. The figures for the exchanges erected by private enterprise are as follows:—

Town.	Population.	Subscribers.	Subscribers per 1,000.
Vienna	1,200,000	1,614	1·34
Prague	294,000	640	2·17
Trieste	133,000	483	3·63
Lemberg	110,000	330	3·00
Graz	100,000	341	3·41
Brünn	82,600	374	4·52
Linz-Urfahr	50,000	186	3·72
Czemswitz	45,000	111	2·47
Pilsen	45,000	134	2·97
Reichenberg	35,000	318	9·08
Bielitz-Biala	30,000	145	4.38

Physical Society.—As we recently announced, a special meeting of this Society will be held at Cambridge to-morrow, May 9th. The programme of proceedings is as follows:—Leave Liverpool-street at 11 o'clock in train with special saloon carriages (first and third class). On arrival at Cambridge at 12:17 the members of the Physical Society will become the guests of the Cambridge members. Lunch in the hall of Emmanuel College, by permission of the Master and Fellows, at one o'clock. Meeting at the Cavendish Laboratory at 2:30, when Papers will be read by Prof. J. J. Thomson and Messrs. W. C. D. Whetham, S. Skinner, W. N. Shaw, and R. T. Glazebrook. Members will afterwards have an opportunity of seeing the Cavendish Laboratory and other University laboratories. At six o'clock there will be tea in Trinity College Combination Room, by permission of the Master and Fellows. Particulars of the Papers to be read will be found in our Societies' Meetings column.

Liverpool Corporation Laboratory.—At the meeting of the Lighting Committee of the Liverpool Corporation, on Monday last, the City Engineer presented a report by the Electric Inspector to the effect that the alterations and enlargements to the test room and office had been completed, and the apparatus formerly in the hands of the Liverpool Electric Supply Company, Limited, had been taken over at a total cost of £392 10s. 6d., and Mr. Yeaman reported that specifications of the instruments required to complete the equipment of the laboratory had been sent to eight first class firms, and a vidimus of offers was submitted. After some discussion the tender of Messrs. Nalder Brothers and Co, for certain instruments, amounting to £264 17s., was accepted, and it was decided to obtain special instruments from White, of Glasgow, and Siemens, of London, at a cost of £88 and £43 8s. respectively. The appointment of a junior assistant in the laboratory was postponed for a fortnight.

Frankfort Exhibition.—The Allgemeine Elektricitäts-Gesellschaft and the Maschinenfabrik Oerlikon have now definitely undertaken to contract for transmitting power electrically from Lauffen to Frankfort, and are bound under heavy penalties to finish the work at the latest by August 15th. There is, therefore, no longer any doubt but that this important experiment, the successful issue of which will greatly interest the scientific world, will soon be an actual fact.—We have received the first three numbers of *Elektrizität*, the official journal of the Exhibition. This journal is profusely illustrated, and contains a large amount of useful information on subjects connected with electricity in general and its display at the Frankfort Exhibition.—The Committee of the Exhibition have decided to reserve a special building, to be opened on June 15th, for a collection of plans, projects, and results of central station working, which they think will be useful, not only in connection with the Municipal Congress but to the general visitor.

Electric Traction on the South Staffordshire Lines.—At the meeting of the Wednesbury Town Council, on Monday last, the Town Clerk reported that he had received an application from the South Staffordshire Tramway Company for the sanction of the Council to the introduction of electricity as a substitute for the steam, upon the Wednesbury and Walsall tram lines. Alderman Williams said objections had also been made to the

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poles proposed to be used, but from what he had seen they were not unsightly but ornamental, and the probability was that some day they would be utilised for public lighting. Alderman Wilson Lloyd, in seconding the resolution, said he was convinced that, by substituting electric traction for steam engines, something would be done for the comfort of the town and of the people. Eventually it was unanimously decided that the application should be granted subject to a proper agreement being entered into with the Town Council, the conditions to be inserted in the agreement to be approved by the General Purposes Committee.

Glasgow.—The special sub-committee of the Town Council on electric lighting, having considered the reports of Mr. Crompton, Sir William Thomson, and Professor Jamieson, have made the following recommendations:—(1) That the Town Council should themselves undertake the laying down of the necessary plant. (2) That the system of supply should, as far as may be found expedient, be in accordance with the reports obtained. (3) That, if the recommendations now made are approved, the matter be remitted back to the sub-committee to arrange for acquiring a suitable site for the erection of a central station, and to take all other necessary steps for carrying out the proposed works. The cost of putting down the plant requisite for supplying 11,000 16 c.p. lamps (exclusive of cost of sites for central station and sub-station) is estimated at £51,307. The sub-committee also suggest that they might be authorised to consider and report whether any, and, if so, what, arrangement could be made with Messrs. Mavor and Coulson with regard to the purchase of their undertaking. The report was considered by the Town Council yesterday, and the matter adjourned for a month.

The Davenport Patent.—In the *Electrical World* of April 25th are printed four letters written by Thomas Davenport, the American inventor of the electric-motor, to the Hon. Elijah Paine, a Justice of the New York Supreme Court and Davenport's financial supporter. The letter dated January 26, 1847, contains the following passage: "I have the opinions of many, with my own, that the use of electro-magnets to propel Prof. Morse's telegraphic apparatus is an infringement on my patent. William P. Elliot, patent agent at Washington, is of the same opinion. You are aware, probably, that my patent gives me the '*application of magnetic and electro-magnetic power as a moving principle for machinery.*' . . . It seems to me, on comparing my invention to that of Prof. Morse, that the telegraphic companies, after running their wires a '*considerable distance*,' and ascertaining that they can magnetise iron at such a distance, should stop, and contract with me and my associates for the right of using electro-magnetic power to propel their telegraphic machinery." Our New York contemporary is of the opinion that the Davenport patent is the most remarkable example of the admission of a sweeping claim to be found in the history of the Patent Office, not even excepting the Bell telephone patent.

The Action of Oils on Metals.—The *American Journal of Railway Appliances* gives some particulars of a series of tests on the action of various oils on the different metals in contact with them. The experiments lasted some twelve months, and the *modus operandi* was as follows: The metals were first thoroughly cleaned in ether and then dried. They were next carefully weighed and placed in closed vessels filled with oil, which were kept for one year at a uniform temperature in summer of 80°F., and in winter of about 50°F. The following were the results obtained:—In the case of iron, seal oil acted the least on it and tallow the most. Bronze was not attacked at all by colza oil and but very slightly by olive oil; it was, on the other hand, vigorously eroded by linseed oil. In the case of lead, the most deleterious lubricant was whale oil, and the best lubricant was olive oil. Whale, lard, and sperm oils were about equally erosive. Zinc seemed to be but little attacked by mineral lubricating oils, the best oil was lard and the worst sperm. Copper was not attacked by any of the mineral oils, sperm oil had the least and tallow the most action on it. Generally speaking, mineral oil attacked the metals under test the least, and sperm oil attacked them the most. For the lubrication of the bearings of heavy machines, a mixture of colza or sperm oil with a mineral oil is recommended, for they have but little action on bronze or cast iron. Tallow having considerable erosive action on iron, its use should be avoided as much as possible.

Electricity on the Stage.—At a New York theatre an attempt was made to impart a little more realism to the usual theatrical horse-race by causing the scenery to move rapidly across the stage. On this occasion the necessary power was obtained from electric motors, owing to the great ease and promptness with which their speed could be varied to suit the exigencies of the race. More recently, at the Théâtre des Variétés at Paris, this device has been considerably improved upon. At the Théâtre des Variétés not only does the scenery change, but the horses, instead of stand-stationary, as at the New York theatre, are trained to actually gallop, while the track underneath them revolves rapidly in the reverse direction. The three tracks are placed parallel to one another, and each consists of a thick carpet fixed on to an endless belt revolving round drums of 5½ft. in diameter by 3ft. broad, arranged 9 yards apart, the belt being supported between the drums by small rollers placed at intervals of 8in. Each belt is driven by a motor through tooth gearing. The speed of the motors is regulated by rheostats, and some skill is necessary in their manipulation, since, while it is necessary to attain the full belt speed of 2,640ft. per minute (30 miles an hour) in under 10 seconds, there must be no abrupt changes. The race lasts 1½ minutes. The motors are supplied with current from accumulators in the Popp sub-station in the Rue Feydau, and with the pressure at 100 volts they require about 100 amperes (13¼ H.P.) on starting, and about 25 amperes (3¼ H.P.) when in full swing.

Amateur Telegraphy.—At Richmond (Ind.), a city containing about 20,000 inhabitants, there exists, says the *Electrical World* of New York, a telegraph organisation known as the Richmond Local Telegraph Company. The organisation is composed of amateur telegraphers, and its object is to secure a means of frequent communication and social enjoyment for its members. Its officers receive no compensation for their services, and the fees charged cover only the actual expenses involved. This private telegraph line has now been in operation some five years, and has proved a fruitful source of amusement and recreation as well as instruction to the members of the Company, several of whom are now occupying good positions secured through the practical knowledge gained in the operation of the private line. The total length of the line is between four and five miles, and extends from one end of the town to the other, in a somewhat irregular course. The members of this small Company have endeavoured to make the line more substantial and permanent in its character than the average private line, and are very proud of the result. Each subscriber is expected to keep his own instruments in proper order, but beyond that is not concerned with the care of the line. The battery, line wire, and materials are the property of the Company, the office connections and instruments belonging to the individual members. An admission fee of $2 is charged to cover the cost of necessary additional battery, and a regular monthly fee of 25 cents is assessed to meet the expense of maintaining the line and battery.

The Naval Exhibition.—The general lighting of this exhibition, which was opened on Saturday last, is carried out by Messrs. Siemens Bros. and Co. The generating plant consists of seven multitubular Davey-Paxman locomotive boilers, working at 120 lbs. pressure; six Willans engines, and three continuous current Siemens' machines, having an output of 1,500 amperes at 120 volts, coupled direct and running at 350 revolutions per minute. This firm also supply two smaller dynamos, having an aggregate output of 72 kilowatts, and a Siemens alternator, furnishing 500 amperes at 80 volts for the powerful search light at the summit of the model Eddystone lighthouse. The mains are of the Siemens lead covered and iron armoured type, and the lighting is chiefly carried out by means of new pattern 9 ampere Siemens arcs, working two in series. Some 10 miles of conductors have been laid, and 200 arc, and about 5,000 incandescent lamps, installed within nine weeks of the signing of the contract. The whole of the telephonic communications connecting the various executive offices and the fire and police stations have been erected by the Universal

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Telephone Company. Amongst the exhibitors are Messrs. Latimer Clark, Muirhead, and Co., who supply the current for lighting the whole of the incandescent lamps in the Camperdown Gallery, and Messrs. Ronald Scott, who show switch boards, and a 11 unit dynamo for the search light over the grand stand. The General Electric Power and Traction Company, Messrs. Greenwood and Batley, Messrs. Clarke, Chapman, and Co., and the Planet Electrical Engineering Company, also exhibit. The exhibition is in a very complete state, and forms a refreshing contrast to the dreary succession of vacant spaces of the average exhibition at the time of opening.

Leeds.—The terms of the Order to be granted to the Yorkshire House-to-House Company have been agreed to by the parties concerned, viz., the Board of Trade, the Leeds Corporation, and the Company. As the Order contains some peculiar clauses, the following brief abstract may be of interest. The maximum price is fixed at 8d. per unit, but the following discounts are to be allowed:—

For 200 hours' consumption—		
	during any quarter	5 per cent.
300	,,	10 ,,
400	,,	15 ,,
500	,,	20 ,,
600	,,	25 ,,
700	,,	27½ ,,
800	,,	30 ,,
900	,,	33½ ,,
1,000	,,	35 ,,

These discounts work out: For 500 hours' use per quarter, under 6½d. per unit; for 1,000 hours, 5 1-5d. per unit. A sliding scale for sharing profits was also demanded by the Corporation, but the Board of Trade objected. As to the terms of purchase by the Corporation, there are no less than three alternative schemes. By Act of Parliament the Company has a right to exist for 42 years. But the Company has agreed to forfeit its rights at the end of 31 years—if required by the Corporation to do so; no goodwill or compulsory purchase is to be allowed for; and only such works as are suitable for carrying on the undertaking are to be valued. Another scheme gives the Corporation the right, after the expiration of 21 years, to purchase the plant at its then value, and to pay, in addition, such sum for goodwill as the arbitrator may determine. Another alternative is that the Corporation may, *at any time*, require the Company to sell the undertaking for such an amount of Leeds Corporation Stock as will produce, by the interest thereon, an annuity of 5 per cent. per annum upon the sum properly expended by the Company and chargeable to capital account. If, however, purchased before the expiration of 10 years, then the Corporation must pay in addition a sum equal to the aggregate amount of a dividend of 5 per cent. per annum on the capital expenditure, less the aggregate amount of the dividends previously declared by the Company.

Bombay.—The proposal for the experimental introduction of electric lighting in a certain area of the City of Bombay has, says the *Indian Engineer*, been modified at the instance of the Municipal Commissioner. Messrs. Volkart Brothers, who are the representatives in India of Messrs. Ganz & Co., of Buda Pesth, are to be invited to send in proposals for the lighting of the road from the Crawford Markets to the Victoria Station, and thence to the Frere Fountain, or so much of that area as the money in hand—rather less than Rs. 60,000—may justify. The original advertisements inviting tenders in England and the United States brought only three tenders. This lack of enterprise was, no doubt, mainly due to the conditions laid down, by which competitors were to bind themselves to provide all the plant necessary, and make the experiment at their own risk for a period of two years certain. At the expiration of the two years there was nothing to bind the Corporation to go on with the experiment, whether successful or not, or to purchase the plant. Some of the largest firms declined to even consider the proposal, on the ground that the risk and the cost would not be counterbalanced by any fair prospect of equivalent return. Under these circumstances, the Municipal Commissioner came to the conclusion that it was useless to ask firms to lay down expensive plant with no security that it would be purchased or the contract renewed after the lapse of two years. He proposed two alternatives—that the Municipality should purchase its own plant at a cost of two and a-half lakhs, or that they should contract with Messrs. Ganz, or some other well-known firm, to light a small area experimentally for a year or two. The second alternative has been approved by the Standing Committee.

The Sims-Edison Torpedo.—The facility and precision with which energy can be applied at a distance by electricity was beautifully illustrated, says *Engineering*, at a private trial which lately took place of the Sims-Edison electrical torpedo at the yard of the Forges et Chantiers de la Méditerranée at Havre. The torpedo consists essentially of two parts, namely, a float from which is suspended at the depth of about 6ft. the torpedo itself. The torpedo consists of four separate compartments. The first contains the explosive, which is exploded electrically. The second is vacant. The third contains about 6,800ft. (1¼ miles) of controlling cable wound into a hollow coil in such a manner that it pays out free from kinks. As the boat proceeds the cable pays out through the "cable tube," which guides it safely past the propeller. The fourth compartment contains a 40 H.P. motor running at 1,560 to 1,600 revolutions per minute, and geared down to 750 to 800 revolutions per minute to drive a 30in. diameter two-bladed screw with 30in. pitch. Aft of the motor is the polarised relay for actuating the rudder. The total weight ready for service is about 1⅓ tons. Two independent currents are transmitted from the shore to the torpedo by means of a concentric cable, the central conductor of which carries the steering current from a small battery, while the outer conductor carries the main current. The resistance of a cable 6,000ft. long is 6 ohms. In designing the motor, efficiency has been to some extent sacrificed to lightness and convenience. The cable absorbs 3,750 watts, and the motor 4,000 watts, or about 8,000 watts in all, that is, 10 H.P. The generator—an Edison "Municipal"—furnishes a current of 25 amperes at 1,300 volts, when running at 1,500 to 1,600 revolutions, that is, rather more than 40 H.P. The motor is two-pole, series-wound, and drives the torpedo over 21 miles an hour. Immediately the torpedo is arrested by coming against a vessel the fact is shown on the ammeter in the circuit. The firing key is then pressed and the charge exploded.

Electricity in Ships of War.—The extent to which electricity is employed in modern warships may be gathered from the following particulars of the electrical outfits of eight vessels recently built and armed at Elswick. In each of the three Colonial cruisers, "Katoomba," "Mildura," and "Wallaroo," the electric light installation comprises 257 16 c.p. and 37 50 c.p. lamps. Each vessel is fitted with two yard-arm reflectors, containing eight 50 c.p. lamps, and two semaphore signalling arrangements, consisting of a box fitted with a mirror reflector, which throws the light from four 16 c.p. lamps on two movable arms of a semaphore. Each vessel has three search light projectors, and a generating plant consisting of two combined sets of "Willans" engines and "Siemens" dynamos, running at 415 revolutions per minute, and giving 300 amperes at 80 volts. The torpedo-tubes in each ship are fired electrically, and the eight 4·7 inch quick-firing guns are also fitted with two alternative methods of electrical firing. In the four smaller Colonial war vessels, recently completed by the same firm, internal electric lighting has not been considered necessary, but each has been fitted with a "Tower" engine and Siemens 80-unit dynamo to supply current to the projector, yard-arm reflector, and semaphore reflector. Each has, moreover, five torpedo tubes, fired electrically from the conning tower, and two 4·7 guns, also fired by electricity. In another recently-completed cruiser of Elswick build, the "25 de Mayo," the electrical outfit consisted of three Parsons steam turbine 16-unit dynamos, supplying current to 190 16 c.p. and 12 50 c.p. lamps, yard-arm reflectors, search-lights, &c. The torpedo tubes are also fired electrically, as well as the two 21cm. guns and the 8 4·7in. guns, while the sights are illuminated by minute incandescent lamps for night service. All these vessels are wired on the double wire system, with lead-cased cable, on the plan originally introduced at Elswick, and the whole of the work was carried out by the Elswick Electrical staff, under the superintendence of Mr. L. Newitt, with Mr. A. A. Campbell Swinton as electrical adviser.

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MAGNETISM IN IRON AND OTHER METALS.*—XL.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 292, Vol. XXVI.*)

§ 141. Effects of Combined Pull and Torsion on the Magnetisation of Iron and Nickel.—The same observers have recently examined, in much detail, the changes of magnetism in iron and nickel, which occur when a rod is subjected at the same time to pull and twist, and Nagaoka has also determined the curves of magnetisation which are given by nickel wires when kept in this complicated condition of stress. Many of the results are of great interest, and space must be found for a brief notice of some of them here.†

In the magnetisation of any of the magnetic metals we may distinguish broadly between three successive stages in the process. There is first the early stage, during which the susceptibility is comparatively small: the curve of magnetisation shows at the beginning a comparatively easy gradient. Then there is

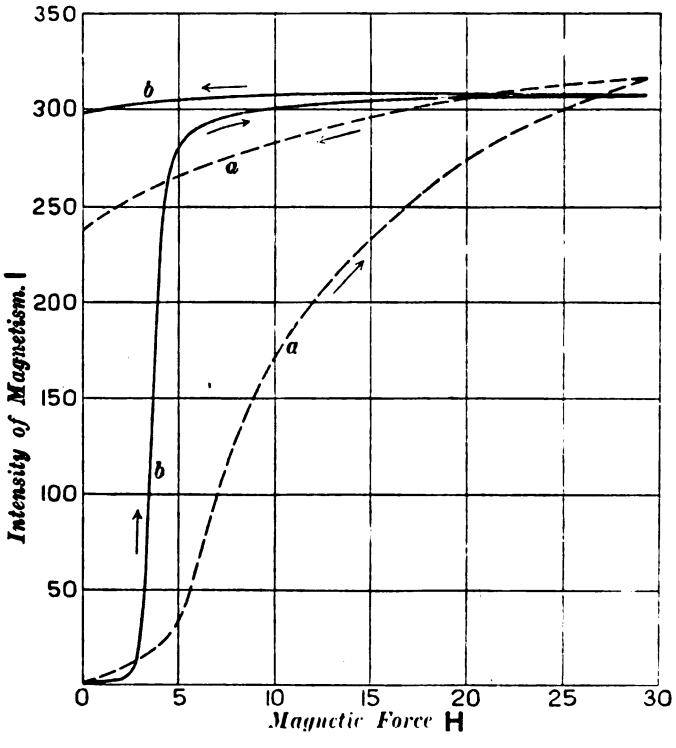

FIG. 120.—Magnetisation of Nickel, *a a*, without torsion ; *b b*, with torsion.

the middle stage, a stage of high susceptibility, when the curve has bent upwards and rises rapidly towards the "wendepunct." Lastly, there is the third stage, in which the condition of the specimen may be spoken of, rather loosely, as nearly saturated. In the third stage the curve has passed the "wendepunct," and has again taken an easy gradient: the susceptibility rapidly diminishes.

In specimens which are free from stress during the process of magnetisation these three stages are to some extent blended, but are still fairly distinguishable, as a reference to any of the figures which have been given for iron, steel, nickel, or cobalt will show. By applying torsion, and still more by applying both torsion and longitudinal pull, it is possible to differentiate the stages to a very remarkable degree. This is shown by Nagaoka's experiments on nickel wires, which are illustrated in the following figures.‡

Fig. 120 shows the influence of simple torsion. The curve *a a* is the ordinary magnetisation curve of a long nickel wire, annealed and tested (without torsion) by applying and removing a magnetising force of about 30 C.-G.-S. units. The curve *b b* was taken while the wire was held twisted, the amount of the twist being 3° per centimetre of length.

As the diameter of the wire was 1 millimeter, the amount of twist corresponds to an angle of shear of $\frac{3 \times \pi \times 0{\cdot}05}{180}$, or 0·0026 radians at the circumference, where the shearing strain is greatest.

The curve taken when the wire was under torsion exhibits some striking differences from the other. In the first place, the initial susceptibility (with respect to feeble magnetic forces) is greatly lowered by torsion. The first part of the magnetising process is sharply distinguished from the second stage. When the second stage is reached, the twisted wire has very great differential susceptibility. Again, the "wendepunct" in it is comparatively sharp. Finally, by comparing the curves got during the removal of magnetising force, we see that the twisted wire possesses much more retentiveness than the other; the ratio of residual to induced magnetism in it has the remarkably high value of 0·97, whereas in the untwisted wire the same ratio is only 0·75. If the comparison of residual magnetisms were made at earlier points in the magnetising process, this difference would be still more marked.

Mr. Nagaoka's experiments further show that when the angle of twist is considerably increased the curve shows a slight tendency to revert towards the normal type (for untwisted wire). It must, however, be borne in mind that any large amount of torsion complicates the conditions of the experiment by making the strain pass the limit of elasticity.

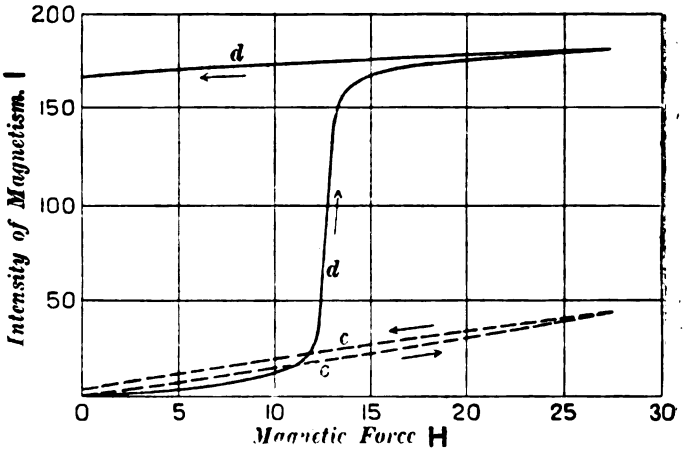

FIG. 121.—Magnetisation of Nickel, *c c*, with longitudinal pull only ; *d d* with longitudinal pull and torsion.

More curious still are the results of combining torsion with longitudinal pull. The application of pull, by itself, has (as was shown in § 121) the effect of lowering the magnetisation curve in nickel. When twist is superposed upon pull the initial part of the curve is still further lowered, but at a moderately great value of the magnetising force a sudden change takes place, the differential susceptibility becomes enormous throughout a narrow range of values of the magnetising force; then comes a somewhat sharp "wendepunct," and the second stage is followed by a third in which there is a slow approach to saturation. Fig. 121 is selected from Nagaoka's curves to illustrate these effects. The wire, which was the same specimen of nickel as before, was loaded with 10 kilos., and the curve *c c* was taken while there was no twist. Here, as the results of § 121 lead us to expect, there is low susceptibility throughout and exceedingly little retentiveness. Next, a twist of 3° per centimetre was given to the loaded wire. The curve of magnetisation was then found to take the extraordinary form shown in *d d*, with reduced initial susceptibility, which lasts through a wide range of force,—followed by an abrupt rise of magnetism in a field of about 12 C.-G.-S., and then high retentiveness. We have here a quite exceptionally sharp definition of the three stages in the magnetising process, and a singularly striking display of hysteresis. The curves of

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† See Papers by Nagaoka, *Jour.* Coll. Science, Imp. Univ., Japan, Vol. II., 1888, p. 283, p. 304 ; Vol. III., 1889, p. 189 ; Zehnder *Wied. Ann.*, 1890, Vol. XLI., p. 210 ; also a Paper by Prof. Knott, *Jour.* Science Coll., Imp. Univ., Japan, Vol. III., 1889, p. 173.

‡ *Jour.* Coll. Science, Imp. Univ. Japan, Vol. II., p. 304.

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Figs. 120 and 121, relating, as they do, to the same specimen, form one group; they are, moreover, drawn to the same scale. *a a* is the normal curve, showing the behaviour of the metal when there is neither pull nor twist. *b b* shows

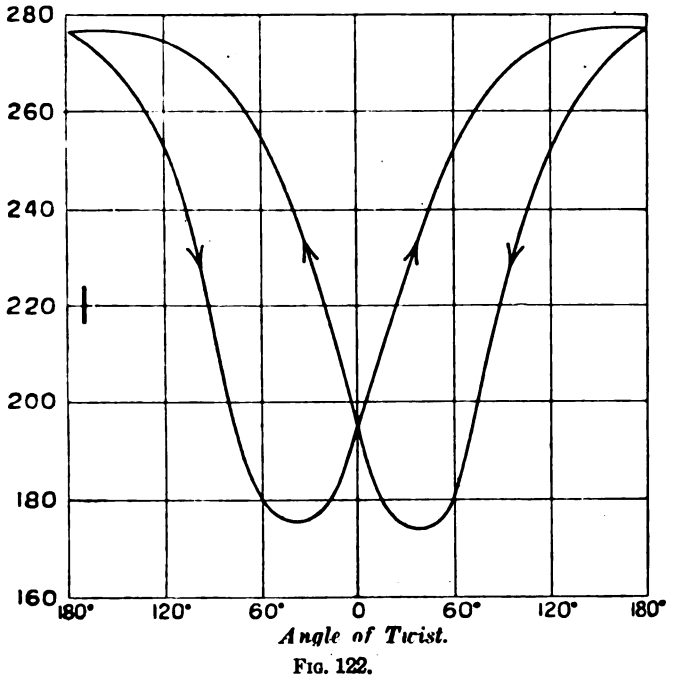

FIG. 122.

the effect of twist alone. *c c* shows the effect of pull alone. Finally, *d d* shows the effect of combining the twist of *b b* with the pull of *c c*. It is interesting to notice that the whole

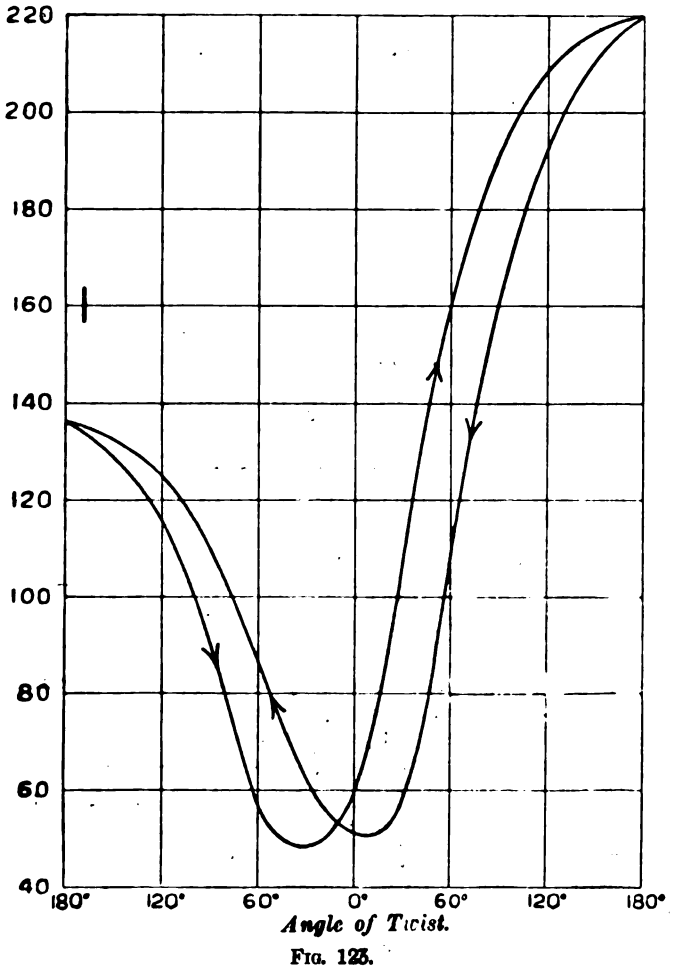

FIG. 123.

amount of magnetism which is acquired during the second or abrupt stage in *d d* is only about half the amount that is acquired during the corresponding stage in *b b*.

The effects of twist which these curves exhibit do not seem capable of explanation by reference to the development of magnetic aeolotropy in consequence of the pull and push components of torsional stress. The inadequacy of this explanation will be even more apparent in the experiments with which the next paragraph deals.

§ 142. Effects of Cyclic Twisting in Nickel, when associated with Longitudinal Pull.—The combination of torsion and pull has been found by Nagaoka to have an even more extraordinary effect on the magnetisation of nickel if the torsion be subjected to cyclic reversals, while the pull is maintained constant.

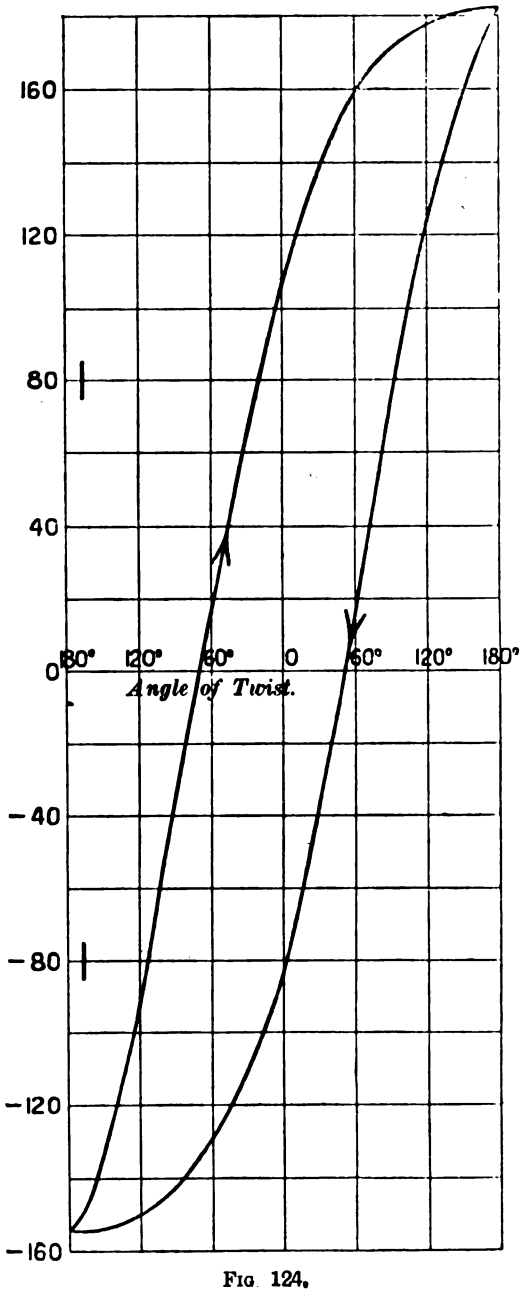

FIG. 124.

Let a nickel wire be exposed to any moderately weak magnetising force in the direction of its length, and let one end be twisted to and fro while the other end is held fixed. So long as there is no longitudinal pull the effects of this alternating torsion are comparatively simple. The curve connecting magnetism with angle of twist has a symmetrical, or nearly symmetrical, form, recalling that found in iron (Fig. 114), but with the important difference that, in nickel, the magnetism increases with twist instead of diminishing as it does in iron. This difference is intelligible enough, in view of the opposite effects of pull in nickel and in iron.

But let the experiment be repeated when a weight is hung from the wire to produce longitudinal pull. It is now found

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that the symmetry of effect is gone. The magnetism is much increased by twisting the wire to the side towards which the earliest twist is directed. Twisting to the other side does not increase the magnetism nearly so much. And if the amount of pull be sufficiently increased, this want of symmetry becomes more pronounced, until a very peculiar result is brought about—that, whereas twisting towards one side increases the magnetism, twisting towards the other side decreases the magnetism, and *may even decrease it so much as to reverse its sign.*

This description will become more intelligible if reference is made to Figs. 122, 123, and 124, which illustrate one of Nagaoka's experiments. The specimen of nickel was a wire 1 mm. in diameter and 40 cms. long, tested in the annealed state. A surrounding solenoid allowed a magnetising force to be applied, which was kept constant with the value 2·47 throughout the experiment. In the first instance (Fig. 122) there was sensibly no longitudinal pull. Repeated twistings from $+180°$ to $-180°$ brought about a cyclic state of things which is represented in the figure. Here the general effect of torsion is that twisting to either side augments the magnetism. Next, a longitudinal pull was applied, amounting to 1·45 kilogrammes per square millimeter, and the process of twisting was repeated. The result was to establish the cycle of Fig. 123, in which the loop of the curve on the side of positive twist is much more prominent than the loop on the side of negative twist. The term positive, as used here, simply distinguishes the direction which happened to be given to the twist in the first instance. The question of which direction of torsion augments the magnetism most depends simply on which is the direction the wire is first twisted in. Next, the longitudinal pull was increased by adding more steady load, and it was found that the positive loop of the curve lengthened, while the negative loop became more insignificant. Finally, the negative loop disappeared, and with a load of 7·82 kilogrammes per sq. mm., the cyclic process took the form shown in Fig. 124, where there is the extraordinary phenomenon of a reversal of magnetic polarity occurring with every reversal of torsional strain, notwithstanding the fact that the force H of 2·47 units was continuously operative in one fixed direction.

It is clear that these effects of twist are not consequences of aeolotropy in the magnetic susceptibility of the twisted material. In fact, the inducing magnetic force plays a very subordinate part in the changes of magnetism which take place when the wire is twisted to and fro, after a cyclic régime is established. Its function is to set up a magnetic condition to begin with; then, as the wire is twisted back and forth, there is with each twist a profound change in the molecular configuration. This is the direct result of the twist, and may, as in the case last described, go so far as to produce reversal of magnetic polarity.

When the magnetising field is sufficiently strengthened, this reversal of polarity does not occur. The inducing force then asserts itself, and the effects of twist come to be more nearly such as might be anticipated from the consideration of aeolotropy. Iron does not reverse its polarity under the combined influence of pull and twist.

(To be continued.)

LIGHTNING CONDUCTORS.

BY DR. OLIVER LODGE.

(Continued from page 754, Vol. XXVI.)

Calculation of the Effect of Radiational Dissipation of Energy on the Length of the B Spark.

§ 63. In order to see whether the suggestion made in the last paragraph, that the effect of iron cores may be to increase the radiational dissipation of energy by the circuit, let us see what the effect of this term is in general. The rate at which a discharging condenser loses its energy by radiation may be expressed in terms of a dissipation resistance coefficient, extra and added to any resistance which the metals of the circuit may have. Call this resistance ρ, then the rate of loss of energy at any instant is

$$\frac{d\left(\frac{1}{2}\,S\,V^2\right)}{dt} = \frac{V^2}{\rho} = \frac{V^2}{3\,\mu\,v\left(\frac{L}{\mu\,l}\right)^2},$$

the last term being obtained in the *Phil. Mag.*, July, 1889, p. 56; l being the length of the circuit, L its inductance, and $\mu\,v$ being 30 ohms.

This conclusion is independent of the capacity of the jars; for, while the rate at which a discharging circuit loses energy depends only subordinately on the circumstances of the conducting portion, so long as it has a simple open contour,[1] it depends not at all on the capacity of the condensing portion.

But though the loss of energy per second is independent of the capacity of the jars used, the *proportionate* loss of energy, on which damping depends, is very much otherwise. For the potential-amplitude at any instant falls exponentially thus

$$V = V_0\,e^{-\frac{t}{S\rho}},$$

and the damping coefficient effective in these alternative path experiments is just this same exponent factor, with t equal to a quarter period or $\frac{1}{2}\pi\sqrt{(LS)}$.

Hence, the extra or radiational damping term is

$$e^{-\frac{\pi}{2\rho}\sqrt{\frac{L}{S}}} = e^{-\frac{\pi\,\mu\,v}{2\rho}\sqrt{\frac{L/\mu}{S/K}}} = e^{-\frac{\pi\,\mu^2\,l^2}{6\,L^2}\sqrt{\frac{L/\mu}{S/K}}}.$$

§ 64. To find what sort of value this term has in ordinary open circuits without iron, we can refer back to the experiments recorded in Vol. XXIII., page 164. The values of S for the cases there treated were—

For the gallon jars (§ 49)	2,890 K centimetres.
For the pint jars (§ 46).....	670 K centimetres.
For the Voss jars (§ 41).....	143 K centimetres.

The self-induction varied with the alternate path and with the three positions of the discharger (Fig. 9). Its smallest value

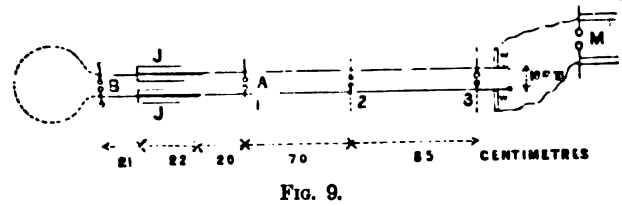

FIG. 9.

for the No. 2 wire and No. 1 position is $2{,}230 + 1{,}290 = 3{,}500\ \mu$ centimetres, or, say, as follows:—

Values of L/μ, *in Centimetres.*

—	Position 1.	Position 2.	Position 3.
Thick wire paths	3,600	5,000	6,700
Medium paths	4,600	6,000	7,700
Thinnest (No. 40) path	5,500	6,900	8,600

So the values of $\sqrt{\left(\frac{L/\mu}{S/K}\right)}$ are about

8 for the thinnest wire, smallest jars, and No. 3 position.
5 for the thick wire, smallest jars, and No. 1 position.
3½ for the thick wire, pint jars, and No. 3 position.
1½ for the medium wire, gallon jars, and No. 2 position.

In none of the cases is this term bigger than 8. As to the value of l, we may suppose that to be about 10 centims only, if we measure it from jar to jar, as the effective length of a horseshoe magnet is measured; and in that case $L = 500\,\mu\,l$. But even if we took it as the whole length of the circuit, so that $L = 10\,\mu\,l$, the radiational resistance would still come out 9,000 ohms, or much too big for the radiational damping term to have any appreciable effect in these particular cases.

This teaches us that while radiation is the principal way in which small linear oscillators like Hertz vibrators get rid of their energy, it is otherwise with our closed circuits with

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electrostatic ends close together, and therefore of great capacity. These dissipate the greater part of their energy by heating the wire; the waves they emit are very long, and the portion of wave broken off and abandoned to space contains but a small fraction of the total energy.

§ 65. Hence, for an explanation of the fact noticed in § 48, that the B sparks from small jars fall below their calculated value, we must look, not to their larger radiation damping term as there suggested (because, though it is larger for small jars than big ones, it is not large enough to be effective), but to the fact that the electrostatic capacity of the B portions of wire has in the calculation been ignored. The capacity of these wires is not unusually enough to have any appreciable influence on the discharge of large jars, but with small ones an appreciable fraction of their relieved charge is occupied in charging up the B leads, and hence the energy of its rush is diluted. That seems to me now the most probable explanation of the very satisfactory agreement with theory shown by large jars, and of the distinctly defective vigour of small ones.

Experiments on the Deflagration of Different Wires.

§ 66. To see how the material of a lightning conductor affects its liability to be destroyed by a flash, a set of exceedingly fine wires supplied by Johnson and Matthey, all of the same diameter, of gold, silver, platinum, and iron, were employed. A scrap of each was laid down on a 4in. glass plate in four parallel lines, between two tinfoil strips, so that the length of each wire was 1·5 centimetres. A number of such plates were prepared. One of the large glass condensers was employed, capacity ·02 microfarads, and the four wires were arranged in its circuit.

Four Wires Parallel.

Spark length of discharge sent through them.	Result.
10 millim.	All four wires deflagrated.
5 „	ditto
1 „	No effect on any.
2 „	Silver deflagrated and smeared on the glass. Copper disappeared bodily, without deposit. Iron and platinum uninjured.
Another plate, 1·5 millim. ...	Silver melted at one end. Copper oxidised. Other two intact.
Same plate, repeated, 1·5 mil.	Copper disappeared with very slight trace. Iron and platinum remain.
Same again, 1·5 millim.	Platinum is deposited in small globules. Iron all right.
Same again, 1·5 „	Iron deflagrated and broadly dispersed.

This is typical of what happened in many trials. When in parallel the best conductor took most of the discharge and was most damaged. The iron having much the highest throttling resistance took very little, until there was no other path open. Even platinum got destroyed before iron.

When the wires are in series, however, so that the same current has to pass through all, the order of their disappearance is inverted, and the iron is distinctly more heated than the others.

Four Wires End to End.

Spark length.	Result.
2 millims.....	Platinum melted into globules. Iron deflagrated; other two uninjured.
Another plate, 1 millim.....	Platinum broken in two near the middle. Iron has evidently been very hot, but is not destroyed. The copper and silver are all right.

(To be continued.)

Atmospheric Electricity.—M. Vaussenat, Director of the Observatory on the Pic du Midi, in order to diminish the electrical potential of storm clouds and prevent the formation of hail, has crowned the crests of the hills around Tarbes, where storms are of regular occurrence, with masts supporting conducting rods. According to the *Bulletin International de l'Electricité*, this device has proved successful.

THE MEASUREMENT OF ELECTRIC POWER GIVEN TO AN INDUCTIVE CIRCUIT.*

BY DR. J. A. FLEMING.

The ingenious method proposed by Messrs. Swinburne, Ayrton, and Sumpner for the measurement of the electric power given to any circuit by any electric current, by means of three voltmeters, is one which, whilst perfect in principle, presents certain practical difficulties in general application.

Suppose, for instance, it is desired to measure the power taken up in the whole of the transformers connected to a transformer station when under light load, and that this has to be done without interfering in any way with the lighting work. In carrying out the measurement, in accordance with the proposed method, it would be necessary to provide a non-inductive resistance capable of carrying the whole current sent out from the station, and which preferably should have such a magnitude that the drop in volts over this resistance should be about equal to the ordinary drop in volts across the primary mains of the transformer station, or, at any rate, not be very different in amount. The alternator would then have to be excited to an electromotive force, higher than the normal, so as to maintain the proper volts between the primary terminals of the transformers. It might be, and generally would be, impracticable to make these arrangements, and the proposed method would, therefore, be inapplicable in such a practical case. It is possible, however, that a modification of this method can be made which will be applicable to such cases, and will enable transformer tests to be made on working primary circuits without interfering with the E.M.F. of the alternator. It is as follows:—Let x (Fig. 1) be an inductive circuit, and let y

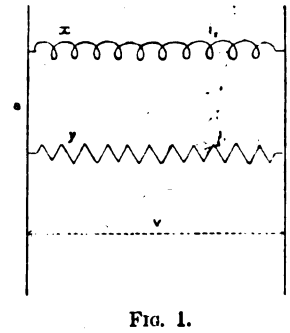

FIG. 1.

be a non-inductive circuit joined in parallel with it between two mains, a and b, between which a potential difference is maintained, which at any instant has the value v. Let i be the current in the main circuit at that same instant, and let i_1 and i_2 be the currents in the non-inductive and inductive circuits y and x also at the same instant; then we have always,

$$i = i_1 + i_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (1);$$

hence,

$$i^2 = i_1^2 + i_2^2 + 2\,i_1\,i_2 \quad . \quad . \quad . \quad . \quad . \quad (2).$$

Let r be the resistance of the non-inductive circuit y, then

$$i_1\,r = v \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3).$$

The power w taken up in the inductive circuit x at that instant is given by

$$w = v\,i_2;$$

hence,

$$w = i_1\,i_2\,r \quad . \quad . \quad . \quad . \quad . \quad . \quad (4).$$

Hence from (2) and (4)

$$i^2 = i_1^2 + i_2^2 + \frac{2\,w}{r} \quad . \quad . \quad . \quad . \quad . \quad (5);$$

or,

$$w = \frac{r}{2}\left(i^2 - i_1^2 - i_2^2\right) \quad . \quad . \quad . \quad . \quad (6).$$

This last equation is true at any instant, hence the mean value of the power, W, taken up is obtained by integration of this equation (6), and is

$$\int_0^T w\,dt = \frac{r}{2}\left(\int_0^T i^2\,dt - \int_0^T i_1^2\,dt - \int_0^T i_2^2\,dt\right);$$

* See *The Electrician*, April 17, 1891, p. 736; also *Industries*, March 27, 1891, p. 306.

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or, $$W = \frac{r}{2}\left(I^2 - I_1^2 - I_2^2\right). \quad . \quad . \quad . \quad . \quad . \quad (7),$$

where I_2, I_1, and I are the readings of dynamometers inserted in the respective circuits x, y, and the main.

To reduce this method to practice, arrange matters thus:—Let T (Fig. 2) be the transformer or transformers on the working circuit, and of which we wish to measure the power taken up in the primary circuit, P. Put a dynamometer, or alternate-current ammeter, a, on the primary circuit, and arrange two others, b and c, as shown in Fig. 2. Let c have a non-inductive resistance in series with it (which may be a water resistance) across the mains. Arrange also a voltmeter, V, across the primary mains to measure the potential difference between them. Then the dynamometer a measures the current I_1 going through the inductive circuit, and c measures the current I_2 through the non-inductive circuit, and b measures the total current. The quotient of the reading V of the voltmeter by the reading I_2 of the dynamometer c gives the value of the resistance r in the formula (7), and hence the power being taken up in the primary circuit of the transformer, is given by the expression,

$$W = \frac{V}{2\,I_2}(I^2 - I_1^2 - I_2^2). \quad . \quad . \quad . \quad . \quad (8).$$

The difference between this method and that of Messrs. Swinburne, Ayrton, and Sumpner is that currents are read instead of volts, and *vice versâ*, and that there is no need for making a call for more electromotive force than would be needed to operate the transformer in the usual way if the measurements were not being made.

The objection which may perhaps be raised to this modification of using the non-inductive resistance in shunt rather than in series is that the same cause of error will be introduced which vitiates the accuracy of a wattmeter reading of alternating current power, viz., that even if the circuit y is made to have as little inductance as possible, yet unless it is quite zero in that respect, the very fact of being joined in parallel with a circuit of possible large inductance will prevent the current in y from being in phase with the electromotive force v. It is

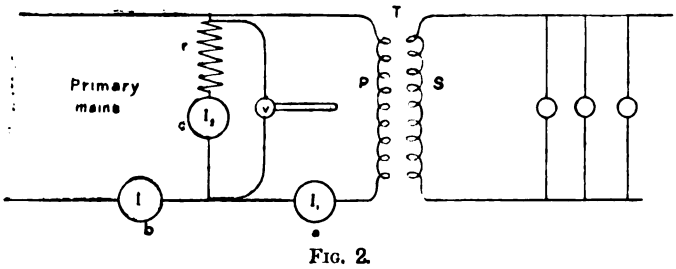

Fig. 2.

possible, however, to settle by direct experiment how far this is the case. Let the two methods, (i.) the one with three voltmeters and non-inductive coil in series, and (ii.), the one with three ammeters and non-inductive coil in shunt, be tried on one and the same highly inductive circuit, and note the difference, if any, in the power reading obtained. If there is no practical percentage of error, I think the method with the three ammeters will prove to have advantages in practice over the other. We want a means of determining the efficiency of house-transformers *in situ*, and that without disturbing the E.M.F. of the primary circuit, and the same is the case in factory tests, where it will often be practically impossible to secure the increased E.M.F. necessary for the three voltmeter method.

ON COEFFICIENTS OF INDUCTION.*

BY A. ANDERSON, M.A.

The following method of measuring the coefficient of self-induction of a coil is somewhat similar to that of Maxwell ("Electricity and Magnetism," Vol. II., Art. 778), inasmuch as a condenser is employed. But it is not a null method; and, although not absolutely necessary for rough determinations, it is desirable to use a ballistic galvanometer on account of the ease with which the throws of the needle can be observed, and because less adjustments and observations have to be made.

In Fig. 1 E is the coil whose inductance is to be found. One pole of the condenser F is joined to D, and the other to a mercury-cup r. G_1 and G_2 are mercury-cups, forming the terminals of the galvanometer, and p, q, and s are mercury-cups connected respectively with A, C, and B. A rocking-key can simultaneously connect G_1 with p and G_2 with q, or G_1 with r and G_2 with s, the galvanometer being in the former case in the branch A C and in the latter in B D, in series with the condenser. The branches A B A D are equal inductionless resistances, and D C, which is also inductionless, is adjusted till as perfect a balance as possible is obtained. When the battery-circuit is made or broken, the galvanometer being in the branch A C, there is a throw of the needle due to the passage through this branch of a quantity of electricity equal to $L\left(\frac{dc}{dx}\right)_{x=0}$, where L denotes the coefficient of self-induction of E, and c the current in the galvanometer, when an additional resistance x is put in the branch B C. The current c is equal to $E\,b\,x/\Delta$, E being the E.M.F. of the battery, and Δ the determinant

$$\begin{vmatrix} a+2R+x, & -R-x, & -R \\ -R-x, & b+G+R+x, & -G \\ -R, & -G, & b+G+R \end{vmatrix}$$

in which a is the resistance of the battery, R of the coil, and G of the galvanometer. Since

$$\left(\frac{dc}{dx}\right)_{x=0} = \left(\frac{Eb}{\Delta}\right)_{x=0},$$

we easily find

$$\left(\frac{dc}{dx}\right)_{x=0} = \frac{Eb}{(b+2G+R)[a(b+R)+2bR]},$$

and therefore the quantity of electricity is

$$\frac{LEb}{(b+2G+R)[a(b+R)+2bR]}.$$

If, by means of the rocking-key, the galvanometer be put in B D,

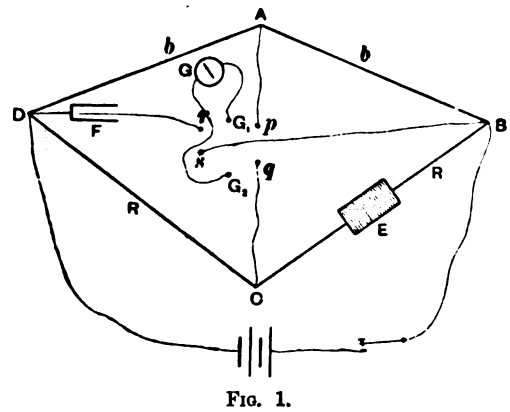

Fig. 1.

and the battery circuit made or broken as before, a quantity of electricity will pass through the galvanometer equal to $K(V_1 - V_2)$, where K is the capacity of the condenser and $(V_1 - V_2$ the final difference of potential between the points B and D. If the capacity K be adjusted till the throw of the needle is the same as before, we have

$$L = K\frac{V_1 - V_2}{Eb}(b+2G+R)[a(b+R)+2bR],$$

which reduces to $$L = 2KR(b+2G+R),$$

since $$(V_1 - V_2)\left(a + \frac{2bR}{b+R}\right) = \frac{2bR}{b+R}E.$$

It may not be possible, with given values of b, R, and G, and a given condenser, to make the throws the same. R may, however, be increased or diminished by the introduction of an inductionless resistance in series or in parallel with it, and the same is true for b and G. A slight change in the formula will then be necessary. If, in this way, we find two nearly equal values of K for one of which the throw of the needle is greater and for the other less than that of the former throw, the correct value of K may be found by proportional parts. But a much better method is to use a ballistic galvanometer, in which case no adjustment of resistances beyond that of getting a perfect balance is required. The two angles of throw α and α' are simply observed, and the coefficient of self-induction is given by the formula

$$L = 2KR(b+2G+R)\sin\frac{\alpha}{2}\sin\frac{\alpha'}{2}.$$

The following determination of the self-induction of a coil may

* Abstracted from the *Philosophical Magazine*, Vol. XXXI., No. 191, April, 1891.

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be given as an example. The coil was a circular coil of mean radius 20·9 centim. wound in a rectangular groove of breadth 1·894 centim. and depth 1·116 centim., and having 278 turns. The galvanometer was an ordinary reflecting galvanometer with a resistance of 164·8 ohms, the controlling magnet being placed so as to make the sensibility as great, and the time of swing as long, as possible. An inductionless resistance of 100 ohms was put in series with the coil, and the resistances of the branches A B and A D were each 10 ohms. A balance was roughly obtained by making the branch C D 150 ohms, and, in the absence of better means, an almost perfect balance by adding to C D a wire whose resistance was subsequently found to be ·51 ohm. The resistance of the branch C D or C B was, therefore, 150·51 ohms. The following numbers are the means of several readings which agreed very well together:—

Kick of needle due to self-induction of coil	= 43·208 scale-divisions.
Kick due to charge or discharge of condenser, capacity ·5 microfarad	= 46·125 ,, ,,
Kick for capacity of ·45 microfarad	= 41·875 ,, ,,

The capacity which would give a kick of 43·208 is found from these numbers to be ·4657 microfarad. The coefficient of self-induction, when reduced to absolute measure, is therefore

$$10^3 \times \cdot 9314 \times 150 \cdot 51 \times 489 \cdot 7 = \cdot 06865 \times 10^9,$$

or, in practical measure, ·06865 henry.

Null Method of measuring the Coefficient of Self-induction of a Coil.

In the method given in Maxwell (Art. 778, Vol. II.) the current through the galvanometer at any moment is zero, but the double adjustment which is necessary is inconvenient. Two methods are given by Mr. Rimington in the *Philosophical Magazine* for July, 1887; but this condition is not fulfilled, and Mr. Rimington shows this for one of his methods. Prof. Niven's methods, given in the *Philosophical Magazine* for September, 1887, do not differ greatly from those given by Mr. Rimington.

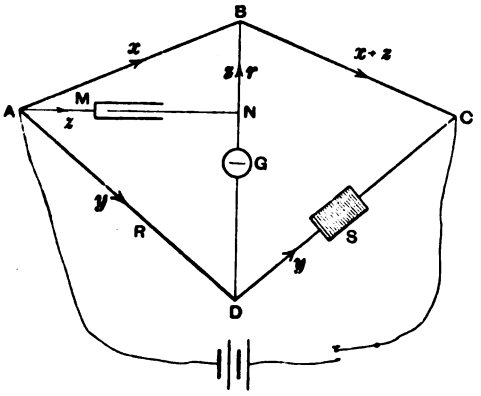

FIG. 2.

The following method, which is but a slight modification of Maxwell's, does away with much of its impracticability.

In Maxwell's method the armatures of the condenser are connected to A and B (Fig. 2), and S is the coil whose coefficient of self-induction is to be found. The only difference in the method now given is that an adjustable resistance r is placed between B and N. Suppose a balance has been obtained so that no permanent current flows through the galvanometer. This balance will not be disturbed by changing r. Let x be the whole quantity of electricity which has passed through A B at the time t, z the whole quantity which has passed through A M, and y that through A D. Then, if K be the capacity of the condenser, and if we suppose the potential of N to be always equal to that of D, we have

$$P\frac{dx}{dt} = \frac{z}{K} + r\frac{dz}{dt}$$

$$\frac{z}{K} = R\frac{dy}{dt},$$

$$r\frac{dz}{dt} + Q\left(\frac{dx}{dt} + \frac{dz}{dt}\right) = S\frac{dy}{dt} + L\frac{d^2y}{dt^2},$$

nd, therefore,

$$(r+Q)\frac{dz}{dt} + \frac{Q}{P}\left(\frac{z}{K} + r\frac{dz}{dt}\right) = \frac{Sz}{RK} + \frac{L}{RK}\frac{dz}{dt}.$$

Hence we have the conditions

$$QR = PS,$$

and

$$r + Q + \frac{Qr}{P} = \frac{L}{RK}.$$

The first is the condition for no permanent current; and the second, which is the condition for no instantaneous current, gives the formula

$$L = K\{r(R+S) + RQ\}.$$

If we make $r = 0$, we get Maxwell's formula. The practical method immediately suggested by the above expression for L is to obtain a permanent balance in the ordinary way, and then to adjust r and, if possible, K, till there is no motion of the galvanometer-needle. Or if, as in Maxwell's method, values of P, Q, R have been obtained, so that there is only a small throw of the needle when the battery-circuit is made or broken, the final adjustment may be quickly and accurately made by introducing an adjustable resistance r, and in doing this a telephone may be employed instead of the galvanometer. It is clear that, if we do this, R and Q must be such that $KRQ < L$.

It seems, therefore, advantageous to make R and P both large, and Q and r both small. Hence the very easy practical method suggested by the formula might not be so sensitive as to obtain first an approximate adjustment, and then to make the final adjustment by varying r.

The following example of the measurement of the coefficient of self-induction of a coil by this method may be given:—The resistance Q being 10 ohms, and P 100 ohms, there was a permanent balance when R was made 1577 ohms, so that S, the resistance of the coil, was 157·7 ohms. A condenser of one microfarad capacity was then placed between A and N, and the resistance r adjusted till there was no kick of the galvanometer-needle. This value of r was found to be 59 ohms, though the sensitiveness was, doubtless, not as great as might have been obtained. Substituting these values, we have

$$L = 10^3 \times (15770 + 59 \times 1734 \cdot 7) \text{ centim.}$$
$$= \cdot 118 \text{ henry.}$$

The same method was also employed to find the coefficient of self-induction of the coil described in (1) of resistance 59·51 ohms. P was made 1000 and Q 10 ohms; and when R was 5051 an almost perfect balance was obtained. Both a telephone and a galvanometer were used in the final adjustment of r, and the value thus found was 3·65 ohms. The coefficient of self-induction is, therefore,

$$10^3 \times (50510 + 3 \cdot 65 \times 5101 \cdot 51) \text{ centim.}$$
$$= \cdot 0691 \text{ henry,}$$

which does not differ greatly from the previous result.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

FRIDAY, May 8th. (To-night).

INSTITUTION OF CIVIL ENGINEERS.

7.30 p.m. Students' Meeting. Paper to be read: "Malta Dockyard Caisson." By J. WALTER BROWN, Stud. Inst. C.E.

ROYAL INSTITUTION.

9 p.m. Evening Discourse. "Liquids and Gases." By Prof. W. RAMSAY, F.R.S.

SATURDAY, May 9th.

PHYSICAL SOCIETY.

2.30 p.m. Meeting at the Cavendish Laboratory, Cambridge. Papers to be read: (1) "Some Experiments on the Electric Discharge in Vacuum-tubes," by Prof. J. J. THOMSON. (2) "Some Experiments on Velocities of the Ions," by W. C. D. WHETHAM. (3) "On the Resistance of some Mercury Standards," by R. T. GLAZEBROOK, (4) "On an Apparatus for Measuring the Compressibility of Liquids," by S. SKINNER. (5) "Some Measurements with the Pneumatic Bridge," by W. N. SHAW.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Artificial Production of Cold." By H. GRAHAM-HARRIS, M. Inst. C.E.

TUESDAY, May 12th.

ELECTRO-HARMONIC SOCIETY.

4.30 p.m. Annual Meeting at 28, Victoria-street, S.W.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary General Meeting. Paper to be discussed: "On Railway-Train Lighting," by WILLIAM LANGDON.

WEDNESDAY, May 13th.

OLD STUDENTS' ASSOCIATION.

8 p.m. Ordinary General Meeting at the Central Institution, Exhibition-road, S.W. Paper to be read: "Some Researches in Electro-Magnetic Induction," by ERNEST B. VIGNOLES, Member.

THURSDAY, May 14th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture. "Recent Spectroscopic Investigations," by Prof. DEWAR, F.R.S.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting. Papers to be discussed: (1) "On some Effects of Alternating Current Flow in Conductors having Capacity and Self-Induction," by Dr. J. A. FLEMING. (2) "Some points connected with Mains for Electric Lighting," by W. H. PREECE, F.R.S.

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The Electrician.

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SCIENTIFIC ACCURACY.

Under the half-ironical title of "Exact Science" we recently made some remarks on hasty generalisations, unsound reasoning, and the confusion wrought by incautious theorising. Students of physics as well as those of other sciences have ever been too fond of propounding theories, not being able to realise the rudimentary state of the subject under consideration, building hypotheses on little else than assumptions, and drawing conclusions, if conclusions they may be called, from most defective premises. BOYLE, one of the founders of the Royal Society, writing in 1675 on the Mechanical Origin of Electricity, observes that heating amber facilitates its electrical excitement, and adds "it is known that heat, by agitating the parts of a fit body, solicits, as it were, to send forth its effluvia, as is obvious in odoriferous gums." He supposed that electrified bodies emitted a glutinous effluvium which laid hold of, or became entangled in, the pores of small bodies in its egress, and upon its return to the body which had emitted it carried them back with it. So much of the early experimental work of this kind was merely qualitative, that the workers were, perhaps, driven to theorising by the natural desire for some result. The chemical doctrine of "definite proportions" was not established until the commencement of the present century, when quantitative analysis was not dreamed of. The physicist of to-day is fully employed with the elaborations of accurate research, the eliminations of disturbing forces, and the computation

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and reduction of his results, that he not only has little time and zeal left for theorising, but his mind is likely to develop in another direction than that which is favourable to the establishment of important theories.

The refinements of scientific accuracy are not yet complete in any branch or department, but we learn this, not from any observed room for improvement in the exactness of results, but from the ever increasing devices for attaining more perfect measurements, for removing causes of error or for the application of corrections. The whole question of the influence of errors on results of scientific observations is an extremely interesting one, but it is generally wrapped up in very obscure mathematical language, dealing with mean squares, summations, and probabilities. If the same measurement be made repeatedly by one observer under similar conditions, he is justified in taking the arithmetical mean of all the readings as the most probable value of the result. But in casting an average it is easy to go on dividing and spinning out a quotient to an absurd number of figures. A young classical master, who has lately joined one of our Northern schools, was requested by the head master to send in a return of the average age of the boys in his class, and in his excess of zeal he calculated it out to half-a-dozen or more places of decimals. Engineers are as a rule content with four significant figures, though, of course, this does not imply a limiting value of 1 in 5,000 throughout their work. The old-fashioned engineer was content with a three-foot rule divided to quarters of an inch, but had a very clear idea of the difference between a driving fit and a working fit, even though this difference is hardly to be appreciated on a modern micrometer. Workshop measurements with electrical instruments may be carried out to-day with any tolerably good instruments to one-half per cent. There is no difficulty in getting one-quarter per cent. with first-class ammeters and voltmeters. It is perfectly justifiable, then, to use four figures if the mean of several observations be taken, but more than four would be of little use. With the apparent error, the mean error, the probable error of the mean, and the reciprocal of its square, *i.e.*, the theoretical weight, engineers very rarely trouble themselves. The scientific man may or may not satisfy himself in private as to the degree of accuracy of his work by determining the errors, but he seldom publishes their value, and life is not long enough for the general application of the method of least squares to ordinary experimental research.

The graphical method of plotting the results of observations on squared paper has been warmly welcomed by engineers, and especially by electrical engineers. The popularity of the method dates approximately from the commencement of electrical engineering, say eleven years ago, when, for want of anything but the expensive "section paper," one had to send to the Continent for the cross-ruled, but not always evenly spaced, paper, which is so commonly used abroad. But it is very remarkable that, although the plotting and drawing of curves of all kinds is so common, little or no advance has been made in dealing with the curves when they have been obtained. No sooner were the characteristic curves of dynamos obtained, than blind attempts were made to find a formula to fit them. Curve tracing is a well-established branch of pure mathematics, but few writers have troubled themselves to discuss the opposite process of curve reduction. There are one or two recognised methods which are suitable for special cases, such as in the simpler forms of harmonic analysis and the computation of the orbits of double stars, but no attempt has been made to treat the subject generally. We do not intend to enter on this occasion on the advantages of curve plotting, but merely wish to point out that an investigation is not complete when a curve has been obtained, and to urge upon mathematicians the great want which exists of *simple* directions for differentiation and reduction of the results into some more or less simple formula or law.

The latest communication that has been made on this subject tends rather to show the limited use of the methods which we have been advocating. Mr. S. Lupton, in the current number of the *Philosophical Magazine*, attacks Prof. Pickering on his laborious research on the hydrates of sulphuric acid. Criticisms while the work was in progress had already been made by Dr. Oliver Lodge and by Arrhenius, and Mr. Lupton acknowledges that the task to which he has applied himself is both ungracious and difficult. He has so many objections to make to the employment of this method for the purpose in question that it is difficult to describe the matter in a few words. The results of experiments were plotted, and curves were drawn through the points. It would seem that the accuracy of the observations was in some cases greater than the accuracy of the graphical method, and it is argued that the process of smoothing the curve by differentiation introduces additional personal error. Mr. Lupton concludes that at all events "in the case of experiments of such extreme delicacy it seems preferable to throw over the graphical method altogether and tabulate the finite differences . . . more especially as they afford a test of how far it is safe to carry the reduced results."

The question resolves itself, then, in this particular research into the magnitude of the mean error of the observations. A number of very useful hints are to be found in the non-mathematical parts of Mr. Lupton's paper, and they need but little modification to make them of great service to those who prefer graphical methods to analytical calculations. The examination of their errors deserves the attention of careful experimentalists, and they would do well to work out occasionally the probable error not only of sets of readings, but of the main result of their work. They might be saved from propounding statements about the significance of small quantities if these turned out to be of the same order of magnitude as the errors.

REVIEWS.

Revision or Examination Sheets—Machine Construction and Drawing. By A. Godfrey Day, A.I.Mech.E, Science Master Technical School and Midland Institution, Birmingham. Edited by E. J. Cox, F.C.S., Head Master Technical School, Birmingham. (London: Percival and Co.)

These appear to be specimen examination papers. It is stated on the back that "the failure of students to pass the May examinations of the Department of Science and Art frequently arises, not so much from want of knowledge of the subject-matter as from a want of familiarity with examination papers and careful practice in examination questions under the guidance of a teacher." A more clear statement of the vicious circle in which the cramming system works has seldom been made. Are examiners made for students, or students for examiners? It is here, in fact, confessed that the examiners are frequently so incompetent, or that the system of the Department is so ill devised, that the "knowledge of the subject-matter" possessed by the students cannot be properly ascertained by the present examinations. There does not seem, according to the author and editor of these papers, to be any need for the examiners to make any change, but it is suggested that the students, *after they have acquired* a "knowledge of the subject-matter," should go in for a course of study of the tricks of examinations. We notice in the illustrations that one of the first principles of machine design, viz., the rounding of the corners of castings, is frequently ignored.

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Practical Perspective. By J. SPENCER, Head Master of the Science Department, Technical College, Bradford. (London: Percival and Co., 1891.)

The scholastic mind having been trained to regard geometry as an excellent educational subject, and "Euclid" as an ideal text-book for teaching the same, is tempted to mould all other cognate subjects into the same lines. The practical requirements of technical education include the study of perspective, and instead of treating the subject in a practical way, a number of books which have recently appeared, have dealt with it in the driest and most involved style. Every engineering draughtsman should have some knowledge of perspective, though he may rarely use it. The rules are extremely simple, and it is one of the few subjects which may easily be thoroughly and completely mastered by any person of ordinary intelligence. The present book is written avowedly for the requirements of certain examinations. It makes no attempt to introduce the principles in simple language, and is needlessly complicated. It may be useful for cramming for the examinations, but cannot be recommended to engineers or draughtsmen, unless for the worked examples at the end.

Traite Elementaire d'Electricite. J. JOUBERT. Deuxiéme edition. G. Masson, Paris, 1891.

This well-known text-book, which first appeared in 1888, had practically dropped out of use in consequence of the rapid developments of electrical science. The present edition has been considerably enlarged, and the theory of alternate currents is dealt with. As in most text-books of this calibre, dynamos, &c., are dismissed in a very few pages, and though this may be justifiable, the examples given ought to be well up to date. The only transformer described is one of the Gramme ring type. The author alludes to the term hysteresis, but prefers "*retard d'aimantation*," or simply "*retard*," which, in his opinion, expresses the same idea with all needful precision, and appears to fulfil all the requirements. We naturally turn to the chapter on alternate currents, for his rendering of "lag," and we find the word "*retard*" again used, a striking example of the poverty of the French vocabulary. Like all other text-books more than 10 years old, this needs severe pruning.

Les Theories Modernes de Electricite. Essai d'une theorie Nouvelle. O. LODGE. Traduit de l'Anglais et annoté par E. MEYLAN. (Gauthier-Villars: Paris, 1891.)

Under this title Dr. Oliver Lodge's well-known "Modern Views" is hardly recognisable. The translator's notes do not call for much remark. He omits to give Dr. Lodge's footnote to his remark on p. 164 (English edition), and appends one of his own, in which he observes that the effect of hysteresis is far from being negligible.

Colour Measurement and Mixture. CAPT. ABNEY, F.R.S. Romance of Science Series. S.P.C.K., London.

If excuses were needed for our noticing this interesting book, other than its own merits, it might be said that optics are a branch of electrical science. The subject of colour has hitherto been dealt with scientifically by only two writers, Ogden Rood and Church. Captain Abney's careful researches have now enabled colours to be accurately specified, so that a dyer could receive an order by telegram.

SPENDING WORK ON THE ETHER.

BY S. TOLVER PRESTON.

Doubtless it will be seen at once, on rejecting the assumption of "force" propagated to a distance without time, that if molecular "attraction" be an electrical stress or any action brought about by the ether pressure, then since "chemical action" (involved in the oxydation of the food) is known to be the receptacle whence the energy of the human body is drawn, it follows that the work expended in separating two electrically charged masses, or a keeper from a magnet, when done by the human body, must be a cyclical process, where energy passes from and to the ether simultaneously—from in the oxydation of the food, and to in the act of separating the two electrically charged masses.

If, then, by any invented device whatever, we could avoid the performance of work in the process of separating (to a distance) the electrically charged masses, or the keeper from the magnet, the conditions as far as the ether is concerned would remain the same as before; for no energy would then pass from and to the ether in the process of separation, which obviously amounts to the same as when equal energy passes from and to (*i.e.*, in the case where work is expended in separation). For we see that in both cases (work and no work) the energy of the ether is unaltered by the process. Hence it must be perfectly obvious that the work performed in separating two electrically charged masses, or a keeper from a magnet, is completely superfluous or serves no practical object whatever, if only a device could be invented to avoid spending work on the ether (or the ether coming into play in the process of separation). It is only the notion of a mysterious unchangeable and unapproachable "force" ("action at a distance") that has led to the idea that it is against theory to attempt to elude the exchange of work in such processes, and also to the further idea that energy is (by the process of separation of the masses) "stored up" in some occult non-material form, for the eventual approach of the two electrica ly charged masses, and, therefore, that the work spent in separating the masses is an abstract necessity—a sort of necessity doctrine therefore. There may be a tendency too much to overlook the fact that electric, also magnetic "attraction" is an ether stress, and that the attempt to operate upon the palpable ether, with the view to elude work that can serve no purpose at all, is a very different thing from trying to imprison the phantom "force."

A FEW CALCULATIONS ON ELECTRICAL SHOCKS FROM CONTACT WITH HIGH-PRESSURE CONDUCTORS.*

BY MAJOR P. CARDEW, R.E.

In connection with the public supply of electrical energy in which very high pressures are used, it is important to investigate the amount of shock to which persons may be exposed by contact with one conductor under various conditions of insulation and electrostatic capacity of the conductors. Serious attention is now being directed to the effect upon the human organism of shocks with steady, intermittent, or alternating currents, and the necessity for exact electrical measurement in such investigations is fully recognised.†

The present opinion upon the subject may be stated to be, roughly, as follows:—The effect of an electric shock produced by the passage of a current through the body during an appreciable time is probably proportional to the square of the current, as regards injury by destruction or heating of tissue, with all kinds of currents; while alternating and intermittent currents produce, in addition, effects upon the nerves and nerve-centres which may be directly injurious in themselves, and are generally indirectly so by producing temporary paralysis, and thus depriving the recipient of the power of terminating the period of contact.

The resistance opposed by the body to unidirectional and to alternating currents of the ordinary frequencies appears to be different, at any rate for low electrical pressures, that with the former being considerably the higher; but this difference diminishes as the pressure is increased, and is probably an effect of polarisation in the tissues.

This resistance is also largely affected by the extent of surface of the body through which the current enters, and the condition of the skin.

Without dealing further, however, with the effect produced, the following calculations merely give the current, or discharge through the body, under different conditions; the electrical impedance to the flow to earth through the body, including the resistances at the point of contact and in the earth connection, being taken as a constant resistance—r for continuous, and r' for alternating currents. The charging source is considered to be in all cases perfectly insulated, of negligible electrostatic capacity, and of ample power to maintain the pressure under all conditions.

* Paper read before the Institution of Electrical Engineers, April 23 1891.

† *Vide* the Papers by Messrs. Stone, Newman Lawrence, and Harries.

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The principle upon which the following calculations are based is, that every electrical machine must at any instant, or during any time, however extended, produce equal quantities of what used to be called "positive" and "negative" electricity.

This fact is as true of a dynamo as of a piece of sealing-wax and its rubber; the emission from the source, whether it be a steady current or a small charge, is equal from the positive and negative pole. Thus, if one pole be connected to a conductor of large capacity, it will necessarily be at a potential nearer to the earth than the other pole, if the latter be connected to a conductor of smaller capacity, and the whole system thoroughly insulated; and in every case this principle determines the potentials from earth of any electrified system, leaving out of question any extraneous charge imparted to it.

The first case to be considered is that of two perfectly insulated conductors, A and B, of considerable cross section, and capacities K and K', kept charged to a steady difference of potential V. The mutual electrostatic induction is assumed to be negligible, and in general will be so, as the conductors are separated by some distance.

The potential of the earth will differ from that of A by an amount $\frac{K'V}{K+K'}$, and of B by an amount $\frac{KV}{K+K'}$, and there will be equal charges on the conductors.

If now a person making good earth with some part of his body touches conductor A with another part, the transmission through him will be not only the charge on A, but the equivalent of the opposite sign to the additional charge flowing to B to raise its potential to V. Thus the quantity that will pass through him will be

$$\frac{KK'V}{K+K'}+\left(K'V-\frac{KK'V}{K+K'}\right)=K'V.$$

The emission from the source being again equal in the two conductors, and amounting to

$$K'V-\frac{KK'V}{K+K'}=\frac{K'^2V}{K+K'},$$

the maximum current through the body will be

$$\frac{K'}{K+K'}\times\frac{r}{V}.$$

Similarly, if contact be made with B, the quantity in the discharge will be K V, the emission from the source $\frac{K^2V}{K+K'}$, and the maximum current $\frac{K}{K+K'}\times\frac{r}{V}$.

Thus it appears that where the capacities of the charged conductors are unequal, contact with the conductor of least capacity will produce the greatest shock, the quantities passing through the body, and currents, being in the inverse proportion of the capacities in the two cases.

This case is perhaps not very practical, as electric supply mains, unless one was an aerial conductor and the other buried, would be, as a rule, equal in capacity. Also, there would be in any length of mains great probability of sufficient leakage to determine the potentials, irrespective of capacity, with continuous currents.

Secondly—Let the conductors A and B be concentric tubes, as in the Ferranti mains, B being outside and entirely enclosing A, except at the two ends, where the conductors are connected to the generator and receiver respectively, or to the generator at one end and the other insulated, which is the simpler case to consider.

In this case there will be no inductive action between the conductors and the earth with the conditions postulated for the generating source, and in the absence of any extraneous charge, and the potential of B with respect to the earth will be zero.

For the quantities on A and B must be equal, and no free charge can be given to B by the source unless it is leaky. If the conductors are transmitting working currents, this condition will be modified by the slope of potential on B, which will then, if insulated, be at zero-potential at the centre of its length.

The same reasoning holds with alternating currents, but in this case the tendency to low potential on the outer conductor is stronger on account of the capacity current.

In fact, with such a length of cable as is used on the Deptford trunk mains—each main having, I am informed by Dr. Fleming, a capacity of about 15 microfarads between the outer conductor and the earth—it would be necessary to have such a considerable leak on the generator or receiver at or near the point of connection to the inner conductor, to raise the potential of the outer much above the earth, that, considering the pressure on the inner conductor, a breakdown must result, and this even if there were no metallic connection to earth on the outer conductor.

It is obvious, too, that no leakage between inner and outer could affect the potential of the latter, except to the extent due to the resulting current and the resistance of the conductor.

The writer pointed out, at the time that the question of the use of an earth connection on these trunk mains was first discussed, that the outer conductor would, even without this connection, always be at a low potential so long as the circuit was in a workable condition; and he has recently been informed that this is found to be the case at Rome.

The earth connections in use have, however, important functions as safeguards in the event of a breakdown in a main transformer.

It is somewhat curious to note that the charge on the outer conductor of the Deptford trunk mains at any instant does not come from the terminal of the dynamo in connection with this conductor, but from that connected to the inner conductor, and passes through the transformer.

Thirdly—Let the capacities of A and B be negligible, but their insulation be no longer perfect, the insulation resistance of A being R, and of B, R'.

Then, with a steady potential difference, the potential of A will be $\frac{RV}{R+R'}$, and of B, $\frac{R'V}{R+R'}$, on the principle of equal emission.

If contact be now made with A, its potential is at once reduced to $\frac{rRV}{rR+R'(R+r)}$,

and that of B increased to $\frac{R'(R+r)V}{rR+R'(R+r)}$;

the current through the body being $\frac{RV}{rR+R'(R+r)}$.

If the conductors have appreciable capacity as well as leakage, there will result in every case a discharge through the body due to the rearrangement of potentials with respect to the earth, since the effect of the contact must be to lower the potential of the conductor touched.

Fourthly—The general case with leakage and capacity with alternating currents.

This requires working out. Let, as before, A and B be the two conductors between which an alternating pressure, maximum V, is maintained at a frequency n; and let them be considered to be separate conductors with negligible mutual electrostatic induction.

Let K be the capacity, R insulation resistance } of A.
K' capacity, R' insulation resistance } of B.
V_a maximum pressure of A from earth;
V_b maximum pressure of B from earth;
$p=2\pi n$.

The current at any instant flowing to each conductor will be compounded of the charging and leakage currents respectively, and the phase angle between the pressure and the current for each conductor will depend upon the capacity and insulation resistance, and will not be the same for the two conductors unless the product of the capacity and insulation resistance is the same for each.

But the current in each conductor must be identical in phase, and equal at any instant, on the principle of continuity.

Therefore, in general, there will be a difference in phase between V_a and V_b, as shown in Fig 1.

Let ϕ be the angle measuring this difference; and, assuming the sine law of variation, we have at any instant the potential $A=V_a\sin\alpha$, and of $B=V_b\sin(\alpha+\phi)$, where α is the phase angle; and as the quantity flowing to each conductor in the succeeding instant is the same,

$$K V_a d(\sin\alpha)+\frac{V_a}{R}\sin\alpha\,dt=$$

$$K' V_b d[\sin(\alpha+\phi)]+\frac{V_b}{R'}\sin(\alpha+\phi)\,dt,$$

$$\text{or } pK V_a\cos\alpha+\frac{V_a}{R}\sin\alpha=pK' V_b\cos(\alpha+\phi)+\frac{V_b}{R'}\sin(\alpha+\phi).$$

Since this equation is true for all values of α, let $\alpha=0$, then

$$pK V_a=pK' V_b\cos\phi+\frac{V_b}{R'}\sin\phi \quad . \quad . \quad . \quad . \quad (1).$$

Again, let $\alpha=\frac{\pi}{2}$,

then $$\frac{V_a}{R}=\frac{V_b}{R'}\cos\phi-pK' V_b\sin\phi \quad . \quad . \quad . \quad (2);$$

whence, $$\tan\phi=\frac{p(KR-K'R')}{1+p^2KK'RR'} \quad . \quad . \quad . \quad . \quad . \quad (3).$$

The straight line joining the extremities of V_a and V_b represents V in phase and magnitude; whence,

$$V_a^2+V_b^2+2V_aV\cos\phi=V^2 \quad . \quad . \quad . \quad . \quad (4).$$

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From these equations the values of V_a and V_b can be deduced in terms of V; but, as the resulting formulæ are somewhat cumbrous, it is simpler to proceed thus:—First, determine ϕ from equation (3); secondly, determine θ, the angle between V_a and C, the current, from the equation,

$$\tan\theta = \frac{p\,K\,V_a}{\frac{V}{R}} = p\,K\,R.$$

The directions of V_a, V_b, and C are thus determined:—Take C of any convenient length on each side of the origin, and from the ends of C drop perpendiculars on V_a and V_b: the distances between the origin and the feet of these perpendiculars are proportional to $\frac{V_b}{R'}$ and $\frac{V_a}{R}$, and may be taken as V_b and $\frac{R'}{R}\ V_a$. This determines the length of V_a and V. In the example shown in Fig 1, $V_b = \frac{V}{2\cdot9}$; or the current through the leak $= \frac{V}{2{,}900}$, maximum.

Fifthly.*—If the insulation of the two conductors be supposed perfect before contact is made with one of them, the equations are simplified.

Let B be the conductor touched, then in the equations R becomes infinity, and $R' = r'$;

whence,
$$\tan\phi = \frac{1}{p\,K'\,r'},$$

and
$$V_b = \frac{p\,K\,r'\,V}{\sqrt{1+p^2\,r'^2\,(K+K')^2}}.$$

Thus the maximum current through the body is given by the equation,

$$C = \frac{p\,K\,V}{\sqrt{1+p^2r'^2\,(K+K')^2}} \quad . \quad . \quad . \quad . \quad . \quad (5),$$

or, if V be virtual volts, this will be the current in virtual amperes.

Here, again, it appears that the discharge through the body varies directly as the capacity, not of the conductor touched, but of the oppositely charged conductor, as has been shown to be the case with unvarying pressure.

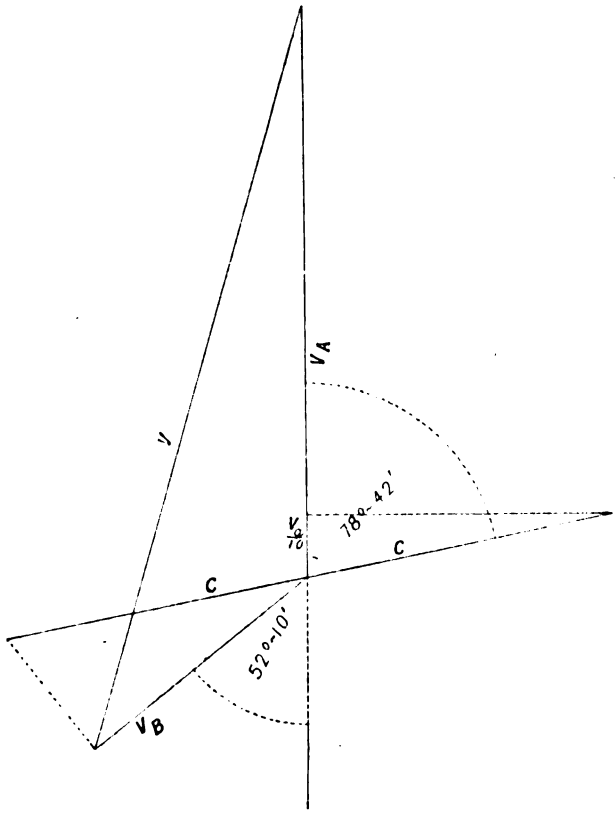

Fig. 1.

* Fig 2 shows the phases and relations of the quantities, V_a in this case being in quadrature with C.

As a rule, with separate conductors, the capacities of each with respect to the earth will be equal, in which case equation (5) is modified to the following:—

$$C = \frac{p\,K\,V}{\sqrt{1+4\,p^2\,r'^2\,K^2}},$$

which may be written, $K = \frac{C}{p\sqrt{V^2 - 4\,C^2\,r'^2}}$,

supposing C, the current through the body, to have the maximum value which may be taken without injury—or, say, 20 milliamperes—r' to be 2,000 ohms, V 2,000 volts, and p to have the value 500, we get from this K about ·02 microfarad only; which clearly shows

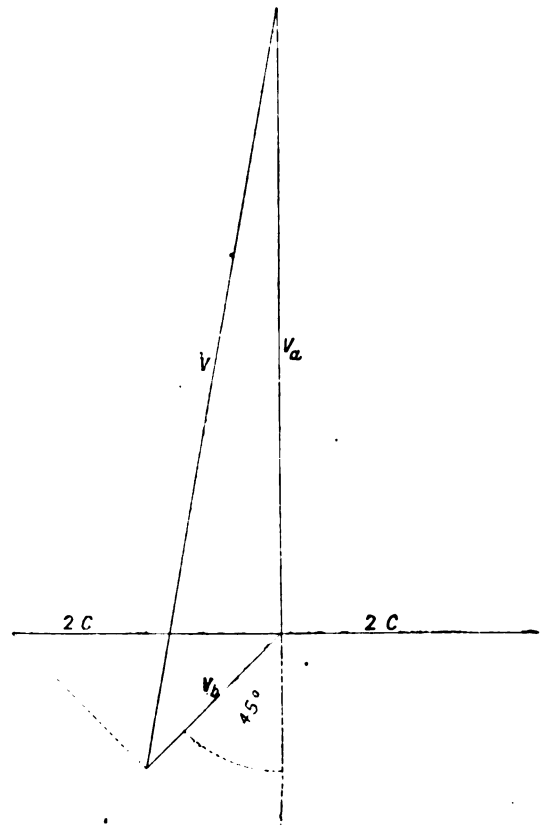

Fig. 2.

the danger of touching bare conductors used for the supply of alternating currents at high pressure, under any conditions.

DISCUSSION (Authorised Abstract).

Dr. FLEMING said the subject treated of was of great practical importance when dealing with pressures exceeding 100 volts. Considerable misapprehension existed on the subject, for it was commonly considered that high pressures were intrinsically dangerous. This, however, was not the case, for, as Mr. Latimer Clark showed years ago, a person could, without injury, receive a shock from hundreds of thousands of volts, provided the quantity of electricity passed through the body was not large. To get a serious shock such as would cause physiological damage it was evident that some appreciable current was necessary. The amount required to produce painful sensations differed greatly, both with different subjects and with the portions of the body through which the current was passed. Some years ago he had tested himself, and found that four or five milliamperes passed through the head produced "swimming in the head," whereas from hand to hand he could tolerate 20 to 30 milliamperes. Some persons might, he thought, be able to take 20 milliamperes through the head. It was not at all unlikely that one-third of an ampere, probably less, passed through any vital organ would prove fatal. Referring to the question as to how the body acts towards the current, whether like a condenser, voltameter, or resistance, he said that the condenser effects were small, but undoubtedly it acted like a voltameter or secondary battery, for it could be polarised, and a current subsequently obtained from it. Measurements of resistance depended greatly on the character and humidity of the skin. At Cambridge, where many experiments were made, it was found that the resistances of boating men from hand to hand were unusually high, and to eliminate more or less the difficulty of obtaining good contact Maxwell suggested that the hands be blistered and connection made by pushing needles through the skin. The experiments were not continued. On the subject of whether a person making a joint in active high-pressure mains, on an insulated chair, he said that if the body acts like a condenser, serious physiological damage might result from a contact under such circumstances, particularly if the current be alternating. The theory that some such condenser action existed was supported by the fact that moderate alternating or fluctuating pressures produced more painful sensations than equal continuous ones. If, however, physiological damage was the result of the electrolysis of some vital tissues, then direct currents would be more likely to prove fatal than alternating currents of the same strength. One interesting fact brought out in Major Cardew's Paper, viz., that the outer conductor of a concentric cable is naturally at zero potential, he had verified

* Cf. "On an Unnoticed Danger in certain Apparatus for Distribution of Electricity," by J. Hopkinson, F.R.S., *Phil. Mag.*, Sept., 1885.

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experimentally, and he considered it an important point in favour of concentric conductors for high-pressure distribution, and thought the fact ought to be more generally known. In conclusion, he said that quantitative information and data respecting electric shocks, accidental or otherwise, were greatly needed, before the subject could be thoroughly investigated.

Mr. H. NEWMAN LAWRENCE said he had made many experiments on the resistance of persons and on the currents required to produce discomfort, &c. He would not like to have passed the four or five milliamperes mentioned by Dr. Fleming through his own head, and thought it improbable that some persons might withstand 20 milliamperes through that part of the body. The direction of the current with respect to the brain was, however, of great importance. Transverse currents produced most effect, and he found it possible to withstand two or three times as much current when passed longitudinally. Although the passage of such currents might not have very serious consequences immediately, the after results might be serious. In commenting on the difficulty in obtaining reliable information in cases of accidents or other serious shocks, he expressed a hope that the Institution might be able to collect such statistics as completely as possible. Generally, he said, the conditions as to area of contact, condition of skin, earth connection, &c., were not at all clear, and no idea could be gathered from ordinary information as to the actual current passed. He agreed with Dr. Fleming that it was the quantity passed through the body that was the important factor. To know the pressure was not essential, and the ordinary statements that persons received shocks from a certain number of volts were generally misleading.

Mr. ADDENBROOKE remarked that in connection with the Grosvenor Gallery installation he had experienced shocks, and once made an overhead joint on a 2,500-volt circuit with the pressure on. To do this he had a strong teak bracket fixed to the posts, and all the wood and metal work near was covered with india-rubber sheeting. Special tools with insulating handles were used, and a dry day chosen. When he touched the conductor faint blue sparks passed, but nothing to produce discomfort. On another occasion he unconsciously put his hand across a high-pressure switch, and, although he had no recollection of experiencing any shock, he was thrown down. Several men he knew had received serious shocks from a 2,500 volt circuit. In one case, a man was putting up a transformer, and, clinging to an iron bracket that had been recently cemented into a wall, with one hand, he reached up to one of the primary conductors with the other. The pressure was on, and the man was fixed in that position until he was pulled down by his comrades. His hands were severely burnt and he received a severe shock to the system. In another case, when rearranging a customer's service lines, an arc started through a crack in the insulation, to the hand of a man who was holding the wire. He was fixed to the post for some time before being released. The hand was badly burnt, and looked as if a red-hot poker had been laid on for some time. He (Mr. Addenbrooke) believed that the arc was started by perspiration from the man's hand penetrating the crack and making connection through his body to the post. So far as he knew, his constitution was not permanently affected by the shock.

Mr. MORDEY remarked that at the Brush Works they had made high-pressure electrical machinery for the last ten years, and although their testing arrangements were of a temporary kind, and much unskilled labour was employed, they had never had a serious accident due to electrical machinery. Only one instance had occurred in which a man was made insensible. This was a lamp trimmer, who, in taking down a lamp, completed the circuit of a No. 8 Brush machine through his body. A bright arc was seen to pass between the lamp and his hand. He fell from the ladder, and had received a severe burn and shock; but, although a large current must have passed, he suffered no permanent injury to the system. He himself once disconnected the circuit of a No. 7 machine, and held the wires, one in each hand, thus completing the circuit. At the time he was conscious of having an idea that the brushes of the machine needed shifting, to reduce the great sparking that occurred; but he did not know what he had done until after he was released by stopping the machine. Referring to Dr. Fleming's remarks about making joints in high-pressure mains by means of insulated chairs, he said there was no difficulty whatever in doing so. The average person had not sufficient capacity to obtain a dangerous shock. At the Brush Works they constantly handled high-pressure wires with bare hands, and rarely found it necessary to take any precaution, unless the pressure exceeded 2,000 volts. Then they merely stood on india-rubber mats. A packer once in their employ was particularly insensitive to fairly large pressures, for he commonly took hold of the terminals of machines giving about 800 volts. His experience with concentric cables confirmed the statements made by Major Cardew and Dr. Fleming, viz., that the outer conductor was at zero potential. In considering the shocks obtainable from a given source, he said the internal resistance of the source was of great importance; and, as an instance, adduced the fact that vacuum tubes, although requiring induction coils giving sparks corresponding to many thousands of volts to work them, were blown to pieces when put on a 1,000-volt alternator.

Mr. H. HUMAN asked Dr. Fleming, that as he considered danger more a question of current than of pressure, whether he would prefer to take hold of the primary terminals of a transformer rather than those of the secondary.

Prof. AYRTON pointed out that the fact of the outside of a concentric cable being at zero potential depended on the outside being near earth. It would not necessarily be so if it was far removed from other conductors.

Prof. PERRY inquired whether the whole concentric system and generator, if insulated, might not be charged to (say) a million volts above the earth potential.

Major CARDEW, in reply to Prof. Perry, said this could only be done by means of an external source, and in his calculations he had postulated the absence of such sources. There was, he said, no doubt that considerable polarisation could be produced in the human body, for he found that its resistance to steady currents goes down as the pressure increases, and tends to a value which is approximately the same as that found by measurements with alternating currents. For small pressures, however, the effects produced by alternating or fluctuating pressures were much greater than with steady ones. He called Mr. Addenbrooke's attention to a fact pointed out in his Paper, viz., that touching a conductor of a (say) 2,500 volt system did not necessarily imply that a shock corresponding to that pressure was experienced, for the act of contact, in reducing the resistance to earth, would probably lower the difference of potential to about one-third of the stated value.

ON SOME EFFECTS OF ALTERNATING-CURRENT FLOW IN CIRCUITS HAVING CAPACITY AND SELF-INDUCTION.*

BY DR. J. A. FLEMING.

The full analytical treatment of the problem of the propagation of an electric current through a conductor possessing capacity and resistance is one which is by no means simple. If to this is added the consideration of the additional condition that both the line and the receiving and transmitting instruments possess self-induction, the problem in its full generality is a very complex one. For certain assumptions as to the mode of variation of the impressed electro-motive force, and with other limitations, it may be said to have been solved for periodic currents; but, if we consider the practical case of receiving and transmitting appliances of variable inductance, it can hardly be said that analysis enables the results of definite arrangements to be completely predicted. Fortunately, in much practical work the additional complications which arise from the simultaneous presence of capacity and self-induction in the system are negligible, but useful, and existing work is not entirely thus limited; and electrical distribution by means of transformers, alternating currents, and concentric cables forces us to regard phenomena due to the co-existence of inductance resistance and capacity in one circuit, which need interpretation, even if only so far as to enable constructive mistakes to be avoided. We have

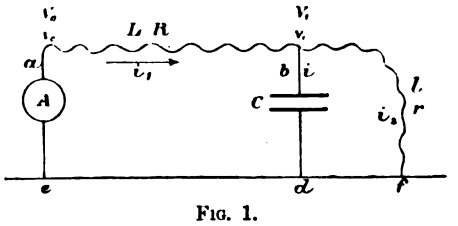

FIG. 1.

already been made aware by experience that under these circumstances unexpected effects often make their appearance, and these demand examination at this period in the history of the large-scale manufacture and distribution of electric current, to enable us to appreciate the meaning of observed facts. The object of the present Paper is to gather together some of the results already arrived at, and to point out a part of the existing state of knowledge of the propagation of alternating currents in circuits in which neither the inductance nor the capacity are so small that they can be left unconsidered in their effects.

2. It will be convenient to start the inquiry by examining a typical and simple case involving simple periodic electromotive force, and inductance and capacity in the circuit. Such problems have already been treated analytically by Dr. Hopkinson; geometrically by Mr. Blakesley, Major Cardew, Mr. Kapp, myself, and others.†

Let A be an alternator feeding an inductive circuit, $a\,b\,f$, of which the section $a\,b$ has inductance L and resistance R, and the section $b\,f$ has inductance l and resistance r. At b let a condenser of capacity C be inserted, and let the terminals e, d, and f of the line condenser and alternator be to earth.

Let v_0 be the potential at a at any instant, and v_1 that at b; and let V_0, V_1, be the maximum values of these potentials, supposed to vary harmonically. Let i_1 and i_2 be the currents at any instant in the sections of the line $a\,b$, $b\,f$, and i the current flowing into the condenser, and I_1, I_2, I, the maximum of the same. Under these circumstances we proceed to investigate what are the relative values of V_0 and V_1, or their ratio to one another. We have always,

$$i_1 = i + i_2. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1);$$

* Paper read May 7, 1891, before the Institution of Electrical Engineers.

† Dr. Hopkinson's Paper on "The Theory of Alternating Currents" is in the *Proceedings* of the Institution of Electrical Engineers (late *Journal* of the Society of Telegraph Engineers) for 1884, Vol. XIII., p. 496. Mr. Blakesley's Papers are collected in his admirable little book on "Alternating Currents."

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also, $$i = C\frac{d v_1}{d t} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2),$$

and $$l\frac{d i_2}{d t} + r i_2 = v_1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3),$$

but we may write, as the currents are simply periodic,

$$i_1 = I_1 \sin p t \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4),$$

where $p = 2\pi n$, n being the frequency of the periodic current in $a\,b$, and t the time reckoned from the instant when the current in this first section is zero.

By elimination of v_1, i_1, and i from the above four equations we find easily that

$$C l\frac{d^2 i_2}{d t^2} + C r\frac{d i_2}{d t} + i_2 = I_1 \sin p t \quad . \quad . \quad . \quad . \quad (5).$$

Since i_2 must also be a simple periodic current, lagging in phase behind that of the current i_1, we may take i_2 to be of the form,

$$i_2 = I_2 \sin (p t - \theta) \quad . \quad . \quad . \quad . \quad . \quad . \quad (6).$$

Hence, by differentiation of (6), and substitution in (5), we arrive at

$$(1 - C L p^2) I_2 \sin (p t - \theta) + C r p^2 I_2 \cos (p t - \theta) = I_1 \sin p t. \quad 7),$$

which, by a well-known transformation, may be put in the form

$$I_2 \sqrt{(1 - C l p^2)^2 + C^2 r^2 p^2} \sin (p t - \theta + \phi) = I_1 \sin p t \quad . \quad (8).$$

Both sides of this equation (8) are expressions for the same thing —namely, the value of i_1—hence, equating coefficients, we have

$$\left(\frac{I_1}{I^2}\right)^2 = (1 - C l p^2)^2 + C^2 r^2 p^2. \quad . \quad . \quad . \quad (9).$$

Putting $a = 1 - C l p^2$, and $b = C r p$, we have,

$$\left(\frac{I_1}{I_2}\right)^2 = a^2 + b^2 \quad . \quad . \quad . \quad . \quad (10).$$

This gives us the ratio of the maximum, or square root of the mean square values, of the currents in the two sections of the line on either side of the condenser.

It is convenient next to shift the origin of the time, and take the instant when the current i_2 is zero as a point from which to reckon the time.

Doing this, we can write,

$$i_2 = I_2 \sin p t \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11);$$

and, accordingly, from (10),

$$i_1 = I_2 \sqrt{a^2 + b^2} \sin (p t + \theta);$$

or $$i_1 = I_2 (a \sin p t + b \cos p t) \quad . \quad . \quad . \quad . \quad (12);$$

hence, $$i_1 - i_2 = I_2 (\overline{a - 1} \sin p t + b \cos p t) \quad . \quad . \quad (13),$$

but from (1) and (2)

$$i_1 - i_2 = C\frac{d v_1}{d t};$$

$$\therefore C\frac{d v_1}{d t} = I_2 (\overline{a - 1} \sin p t + b \cos p t);$$

or $$v_1 = \frac{I_2}{C p} (b \sin p t + \overline{1 - a} \cos p t) \quad . \quad . \quad . \quad (14);$$

$$\therefore V_1 \frac{I_2}{C p} \sqrt{\overline{a - 1}^2 + b^2} = I_2 \sqrt{r_2 + p_2 l_2} \quad . \quad . \quad (15).$$

We have next to find the value of V_0.

$$v_0 - v_1 = L\frac{d i_1}{d t} + R i_1 \quad . \quad . \quad . \quad . \quad (16),$$

and if we substitute in (16) the value of i_1 given in (12), and of v_1 given in (14), and integrate, we arrive at

$$v_0 = I_2 \left\{ \left(R a + \frac{b}{C p} - L p b \right) \sin p t + \left(R b + \frac{1 - a}{C p} + L p a \right) \cos p t \right\};$$

but, since $\frac{b}{C p} = r$, and $\frac{1 - a}{C p} = p l$, we get by proper substitution in the above equation, and by the application of the rule for harmonic maxima, the equation,

$$V_0 = \frac{I_2}{C p} \sqrt{(A^2 + B^2)(a^2 + b^2) + 2 B b - 2 A a + 1} \quad . \quad . \quad (17),$$

where

$$A = 1 - C L p^2; \qquad a = 1 - C l p^2;$$
$$B = C R p; \qquad b = C r p.$$

Equations (15) and (17) give us the values of the maximum or mean potentials at the generator and condenser end of the line $a\,b$. If we divide equation (17) by equation (15), we get a value for the ratio of V_0 to V_1. A little tedious process of division and substitution brings us finally to the required result, which is,

$$\frac{V_0}{V_1} = \sqrt{(A^2 + B^2) + (1 - C p^2)\frac{R^2 + p^2 L^2}{r^2 + p^2 l^2} + \frac{2 L l p^2}{r^2 + p^2 l^2} + \frac{2 R r}{r^2 + p^2 l^2}} \quad (18).$$

This last equation furnishes us with the required result, viz., the ratio of the maximum or mean potentials at the ends of the inductive line $a\,b$ in terms of the coefficients of inductance, capacity, and resistance.

Given V_0. it enables us to calculate V_1, and to say whether V_1 is greater than, less than, or equal to V_0.

3. Let us examine some particular cases. Suppose $r^2 + p^2 l^2 = x$ — that is, suppose the section of the line beyond the condenser removed—then

$$\frac{V_0}{V_1} = \sqrt{A^2 + B^2} = \sqrt{(1 - C L p^2)^2 + C^2 R^2 p^2} \quad . \quad . \quad (19).$$

This reduced case was treated by Dr. Hopkinson long ago,* and he showed, as we can easily see, that it is possible for the ratio of V_0 to V_1 to be *less* than unity—that is, for the potential at the receiving end, or at the condenser, to be *greater* than the potential at the sending end.

It is very easy to state the conditions under which this is the case. In order that V_1 shall be greater than V_0, or that there may be a rise of pressure, we must have

$$\sqrt{(1 - C L p^2)^2 + C^2 R^2 p^2}$$

less than unity ; hence we must have

$$(1 - C L p^2)^2 + C^2 R^2 p^2 < 1,$$

or $$1 + C^2 L^2 p^4 - 2 C L p^2 < 1 - C^2 R^2 p^2,$$

or $$C < \frac{2 L}{R^2 + p^2 L^2} \quad . \quad . \quad . \quad . \quad . \quad (20).$$

If L, R, and p are constant, the value of C which makes the ratio of V_1 to V_0 a maximum is

$$C = \frac{L}{R^2 + p^2 L^2}$$

Hence, if the capacity, C, of the condenser, measured in farads, is *less than* the quotient obtained by dividing twice the inductance of the line L, measured in henrys, by the square of the impedance ($R^2 + p^2 L^2$), we shall, under these circumstances, find a rise in pressure at the condenser end. For example, suppose the value of n or the frequency is 67, then $p = 421$, and $p^2 = 177{,}241$. If R = 1 ohm, and L = ·1 henry, then $R^2 + p^2 L^2 = 1{,}773$, and there ought to be a rise in pressure if C is greater than 112 microfarads ; or, if R = 1 ohm, and L = 100 henrys, then $R^2 + p^2 L^2 = 1{,}772{,}410{,}000$, and there ought to be a rise in pressure if C is greater than one-eighth of a microfarad. Generally speaking, the greater L, the less will be the critical value of C. For high frequencies the criterion of rise of pressure at the condenser end is

$$C < \frac{2}{L p^2}.$$

That is to say, the critical capacity is just twice that which will at the given periodicity nullify the inductance of the armature circuit. It is worth while to note that even if the criterion for rise of pressure at the condenser end is fulfilled by L, R, C, and p, yet, as seen from equation (18), a sufficiently small impedance ($\sqrt{r^2 + p^2 l^2}$) in the shunt may nullify the effect and force V_1 to be less than V_0.

4. These *condenser effects*, as they may be called, are very strikingly shown when currents of high frequency are used. Quite recently, Mr. Nikola Tesla has published some interesting observations and experiments on alternating currents with the very high frequencies of 10,000 to 20,000 alternations per second,† and amongst these he has described an experiment with a condenser joined across the poles of such an alternator. A machine was used giving about 20,000 alternations per second. Two bare wires about 20 feet in length were attached to the poles, and their ends connected to the terminals of a condenser. The difference of potential between parallel points on these wires was explored by a voltmeter, and it was found that the potential difference of parallel points on the wires steadily rose inch by inch from 65 volts at the terminals of the alternator to 120 volts at the terminals of the condenser ; and the writer states that observations on the self-induction of the armature in its position of maximum and minimum inductance showed that the capacity which gave the greatest rise at the condenser end corresponded apparently to that which would about nullify the mean self-induction calculated from the observed maximum and minimum. This entirely corresponds to the above theoretical deduction.

5. The fact that when a condenser is thus charged by an alternating-current machine its terminal potential difference may be very much greater than that of the machine terminals, appears to have been noticed experimentally prior to the time when the simplest case was mathematically treated by Dr. Hopkinson. In the paper of the latter, above referred to, it is mentioned that Dr. Muirhead had observed it experimentally. In the discussion which

* See *Proceedings* of the Institution of Electrical Engineers for 1884, page 513.

† See *The Electrician*, March 6 1891, p. 549.

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followed Dr. Hopkinson's paper, Mr. Blakesley dealt with the same matter in some geometrical diagrams, and Prof. Ayrton mentioned that in 1878 or 1879 Mr. Munro took out a patent for the use of condensers in combination with an alternating-current machine. In any case, the experimental verification of a rise of pressure along the line leading from the machine to the condenser is complete.

6. In his book on "Alternating Currents," p. 55 (2nd edition), Mr. Blakesley has treated by his geometrical methods the case examined above, with the object of showing that the employment of a condenser in this manner in combination with a pair of inductive circuits may, under certain conditions, cause the current in the remote, or shunt, circuit to be greater than the current in the circuit in connection with the machine; and he shows there that a similar criterion to the one given above applies also to the relative current-strengths in the two sections—viz., that the current I_2 in section $b\,f$ will be greater than the current I_1 in section $a\,b$ if C is less than $\frac{2\,l}{r^2+p^2\,l^2}$.

Hence, generally, we have that the maximum or mean potential V_1 at the terminals of the condenser will be less than, equal to, or greater than the maximum or mean potential at the terminals of the machine V_0, according as the capacity, C, of the condenser is greater than, equal to, or less than the quantity, $\frac{2\,L}{R^2+p^2\,L^2}$, in numerical value; and also that the maximum or average current-strength in the remote, or shunt, section of the line will be less than, equal to, or greater than the maximum or mean current-strength in the section of the line near to the machine, according as the capacity, C, of the condenser is greater than, equal to, or less than the quantity, $\frac{2\,l}{r^2+p^2\,l^2}$, in numerical value.

Note that if R is measured in ohms and L in henrys, C must be measured in farads.

If we look again at the equation,

$$\left(\frac{V_0}{V_1}\right)^2=(1-C\,L\,p^2)+C^2\,R^2\,p^2,$$

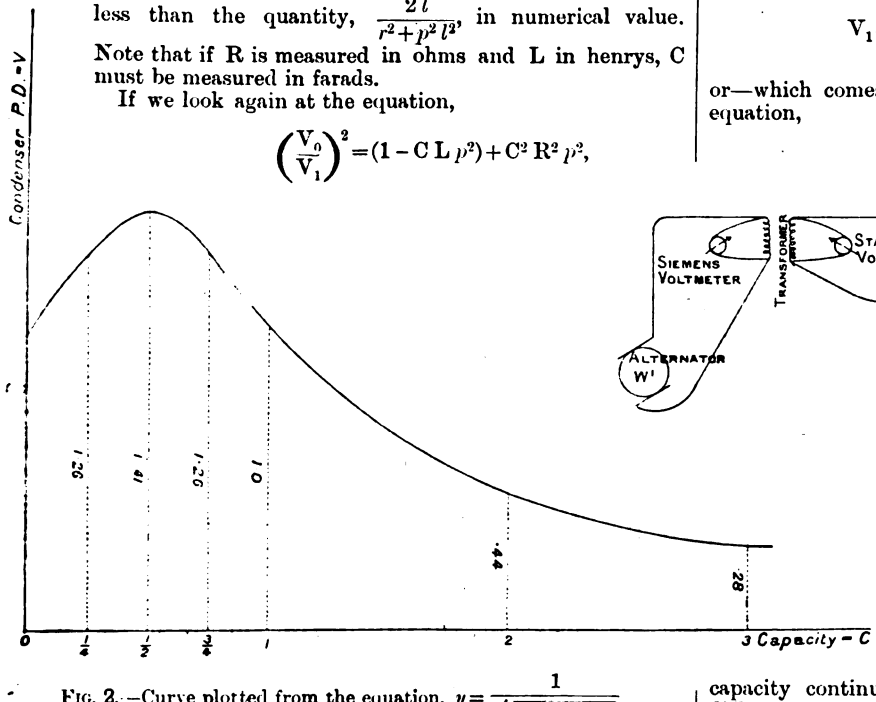

FIG. 2.—Curve plotted from the equation, $y=\frac{1}{\sqrt{(1-X)^2+X^2}}$

or $$V_1=\frac{V_0}{\sqrt{(1-C\,L\,p^2)^2+C^2\,R^2\,p^2}}.$$

and note what are the conditions under which V_1 will be *greater* than V_0, or the pressure at the condenser end greater than the pressure at the machine end of the line, we see that it depends upon whether the right-hand expression, when worked out numerically, is a proper fraction. Since almost any capacity which occurs in practice is numerically represented by a very small fraction when the farad is the unit, if p^2 is not very great $C^2\,R^2\,p$ will nearly always in practice be a proper fraction when we insert values of C and R in farads and ohms. Hence the condition of rise of pressure will depend almost always on whether $C\,L\,p^2$ is numerically greater than 2 when C and L are measured in farads and henrys; and if C is very small, either L or p must be very large to secure this result, and *vice versâ*. Hence, generally, if the inductance of the machine circuit is very large, a comparatively small capacity across its poles may give rise to a very great condenser effect; but if the inductance of the machine is small, a very large capacity will be needed to bring about the increased pressure at the terminals of the condenser.

Suppose, for instance, that a transformer is used to raise the pressure of an alternator, and that across the high-pressure terminals of the transformer is placed a condenser of capacity C, this may be either a condenser of the ordinary form, or a certain length of concentric cable insulated at the far end and having a definite capacity. Let us suppose that the high-pressure circuit of the transformer has a great many turns of wire. The mean inductance of this high-pressure coil is then the L in our formula, its resistance is our R, and p^2 is $4\,\pi^2 n^2$, where n is the frequency of the alternator. To fix our ideas, let $n=83=10{,}000$ alternations per minute, then $p^2=273{,}947$.

Let R = 10 ohms, and L = 200 henrys—values possible to be reached in practice—then, if C is measured in microfarads, we see that that $(1-C\,L\,p^2)^2+C^2\,R^2\,p^2$ becomes

$$\left(1-\frac{C\times 273{,}947\times 200}{10^6}\right)^2+\frac{C^2\,27{,}394{,}700}{10^{12}}=(1-55\,C)^2+\cdot 00003\,C,$$

nearly.

If C is absolutely zero, the value of this quantity is unity. If C is equal to 1-27th of a microfarad, this quantity is also, roughly, equal to unity. If C has any value between zero and 1-27th of a microfarad—say 1-50th of a microfarad—then, since $\left(1-\frac{55}{50}\right)^2+\cdot 00003\,\frac{1}{50}=\cdot 01$, nearly, we see that the ratio of V_0^2 to V_1^2 will be 1 to 100, or V_1 will be ten times V_0. Hence it is obvious there is a narrow range of capacity within which the pressure at the condenser terminals may be enormously increased over that at the machine terminals; but if the capacity is altered so as to take it outside these critical limits, the so-called resonance effects will vanish.

The best way to see how the value of V_1, or the condenser potential, varies with variation of the capacity, other quantities being constant, is to plot the equation,

$$V_1=\frac{V_0}{\sqrt{(1-C\,L\,p^2)^2+C^2\,R^2\,p^2}}$$

or—which comes to the same thing, and is simpler to plot—the equation,

$$y=\frac{1}{\sqrt{(1-x^2+x^2}}.$$

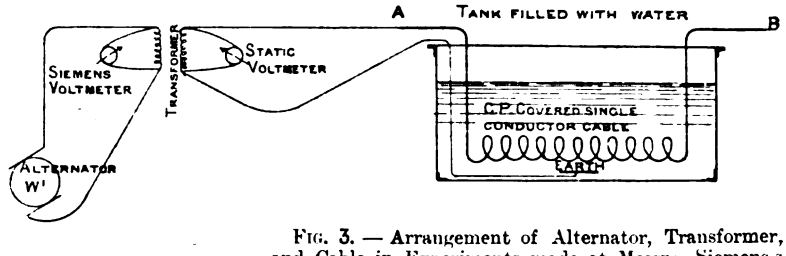

FIG. 3. — Arrangement of Alternator, Transformer, and Cable in Experiments made at Messrs. Siemens's Works.

This has been done in Fig. 2, and a curve representing the variation of V_1 in terms of C, or of the condenser plate potential difference in terms of its capacity, supposed variable, is there drawn, on the assumption that V_0, L, R, and p^2 have certain constant values. We see that the curve ordinate has a maximum corresponding to a certain capacity, and that beyond that point increase in capacity continuously diminishes the condenser plate potential difference.

The condenser effect will be at a maximum when C and L have such magnitudes that $C\,L\,p^2$ is unity, and C has at the same time a small value. In this case V_1 may be hundreds or thousands of times greater than V_0. In testing condensers with alternating-current machines, it is very important not to have that particular critical relation between C, p, and L, or the capacity, frequency, and inductance of the machine, which will bring about the resonance effect, or else the testing process may be a destructive process as far as the condenser is concerned.

8. Quite similarly, we can show that if the capacity of the condenser is fixed, there is a certain range of inductance of the circuit of the alternator within which the resonance effect takes place. For example, let C = ·1 microfarad, as before, $p^2=273{,}947$, and R = 10 ohms, then for the ratio of V_0^2 to V_1^2 we have the value

$$\left(1-\frac{273{,}947\,L}{10^7}\right)^2+\frac{273{,}947\times 100}{10^8}=(1-\cdot 027\,L)^2+\cdot 27.$$

If L = 0, this ratio is greater than unity; if L = 74, the ratio is again greater than unity; but for values of L between 0 and 74, the ratio is less than unity. In other words, within these limits of the inductance the pressure at the poles of the condenser is raised.

The above theory is shown to be confirmed in its general character by the results of some highly interesting experiments, made more

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than a year ago (April 10, 1890) at the works of Messrs. Siemens Bros., which Mr. Alexander Siemens has sent to me. A Siemens W_1 alternator

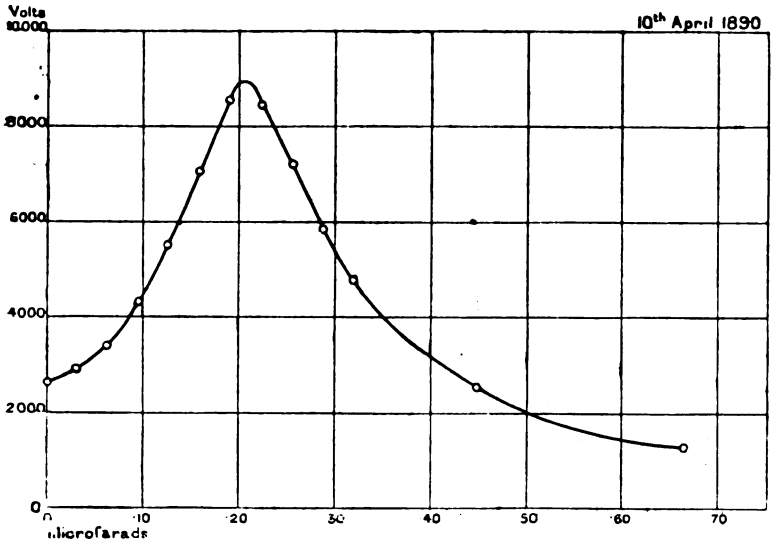

FIG. 4.—Curves showing Variation in Voltage in Secondary (high voltage) Circuit by Varying Capacity in Secondary (high voltage) Circuit. The experiments have been made with No. 2 transformer, and current was obtained from W′ machine, frequency being 100 ∿. The exciting current was constant, and the alternator was running at 750 revolutions during all the experiments.

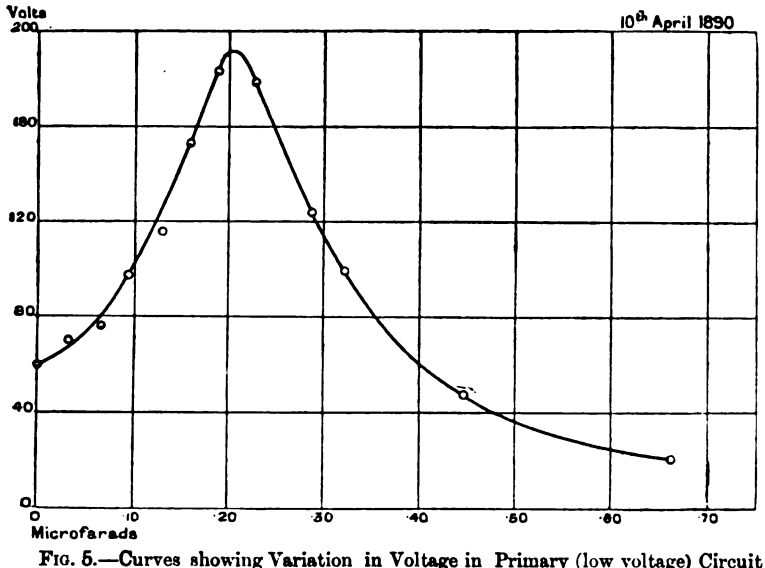

FIG. 5.—Curves showing Variation in Voltage in Primary (low voltage) Circuit by Varying Capacity in Secondary (high voltage) Circuit. The experiments have been made with No. 2 transformer, and current was obtained from W′ machine, frequency being 100 ∿. The exciting current was constant, and the alternator was running at 750 revolutions during all the experiments.

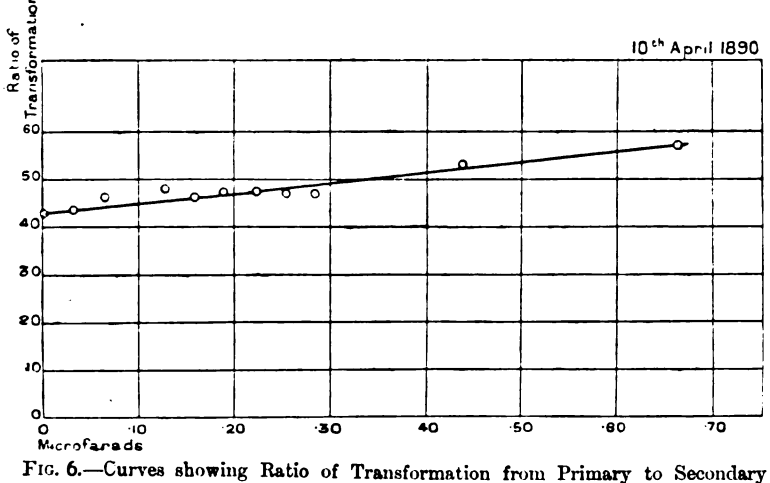

FIG. 6.—Curves showing Ratio of Transformation from Primary to Secondary Circuit resulting from Figs. 1 and 2.

was kept running at a constant speed of 750 revolutions, and the exciting current was also kept constant. The current from this was sent into the thick-wire coil of a No. 2 transformer. The terminals of the fine-wire circuit were connected to various lengths of single-conductor cable, having gutta-percha insulation and immersed in a tank; the cables being insulated at the far ends, and forming thus a condenser attached to the secondary of the transformer (see Fig. 3). The pressure was measured at the terminals of the machine, and at the terminals of the transformer on the secondary, or condenser side. The experiments consisted in varying the length of the cable used so as to vary the capacity, and in observing the pressure at the two sides of the transformer whilst the dynamo was kept running at constant speed and excitation. The results are embodied in the following series of interesting curves. The horizontal distances in the diagrams represent the various capacities of the open-circuit cables or condenser attached to the terminals of the secondary of the transformer. The vertical ordinates in Fig. 4 represent the observed potential difference of the two surfaces of this condenser—that is, the potential difference at the secondary terminals of the transformer.

It will be seen from Fig. 4 that when the capacity is zero this potential difference was 2,500 volts. As the length of cable was increased continuously, this potential difference rose up to 8,500 volts, corresponding to a capacity of ·2 microfarad, and then fell again to 2,500 volts, at a capacity of ·45 microfarad. Hence, corresponding to a certain capacity—viz., ·2 microfarad—the pressure is multiplied about 3½ times, and there is a certain narrow range of capacity over which this exaltation of pressure takes place. At and beyond ·45 microfarad capacity, the presence of the condenser reduces the normal pressure continuously. The pressure on the primary side of the transformer is also increased, as shown in the curve given in Fig. 5, which represents a series of similar pressure observations taken on the primary side of the transformer. It will be seen that the same general effect takes place on the primary side. It will be seen how entirely these curves deduced from observation agree with the theory as illustrated by the curve in Fig. 2. The curves in Figs. 4 and 5 are generally similar, but, if superimposed, will be found to be not quite so. If the ratio of corresponding ordinates is set off so as to form a fresh curve (Fig. 6), this curve will give the variation of change ratio of the transformer corresponding to the various capacities, and we see that this change ratio is altered progressively from 1 : 43 to 1 : 57, as the capacity of the condenser on the secondary is changed from zero to ·65 microfarad. It is evident, therefore, that in applying transformers to test cable, such as concentric cable, which possesses sensible capacity, we must be on our guard against this alteration of the change ratio of the transformer, or else we may be misled as to the real pressure being applied to the cable.

(To be continued.)

THE ELECTRIC TRANSMISSION OF POWER AT HIGH-PRESSURE.

In a letter to the *Elektrotechnische Zeitschrift* several criticisms were recently made by Herr Aug. Schneller, with regard to the Oerlikon transmission of power experiments.* Let us examine, he says, the losses which are likely to occur on *the actual line* between Lauffen and Frankfort. The power in the primary circuit is to be about 186,000 watts, say 30,000 volts and 6·2 amperes. In a copper wire 5 mm. in diameter and 350 kilometres long, the fall of pressure will amount to 1,830 volts or 6·1 per cent. If we suppose the conductor to be an aërial one, supported at every 50 metres, we shall have 3,500 posts and 7,000 insulators. A good oil insulator will offer a resistance of 1,000 megohms to a low-pressure. With 7,000 insulators, we have, therefore, an insulation resistance of 150,000 ohms, allowing a leakage current of ·2 ampere, or 3·2 per cent. But, according to Herr Schneller, at 15,000 volts the loss through a well-dried insulator amounts to 2·3 watts, to 4·7 watts at 20,000 volts, and to 15 watts at 30,000 volts, which gives a total loss of 100,000 watts on the Frankfort line, without taking into account fog or rain. The possible leakage between the conductors themselves Herr Schneller thinks may amount to ·15 watt per metre, or 26,000 watts in all. Taking these factors Herr Schneller comes to the conclusion that only 37 H.P. will be available at Frankfort. But this is not all. Taking the striking dis-

* See *The Electrician*, Vol. XXVI., March 27, 1891, p. 637.

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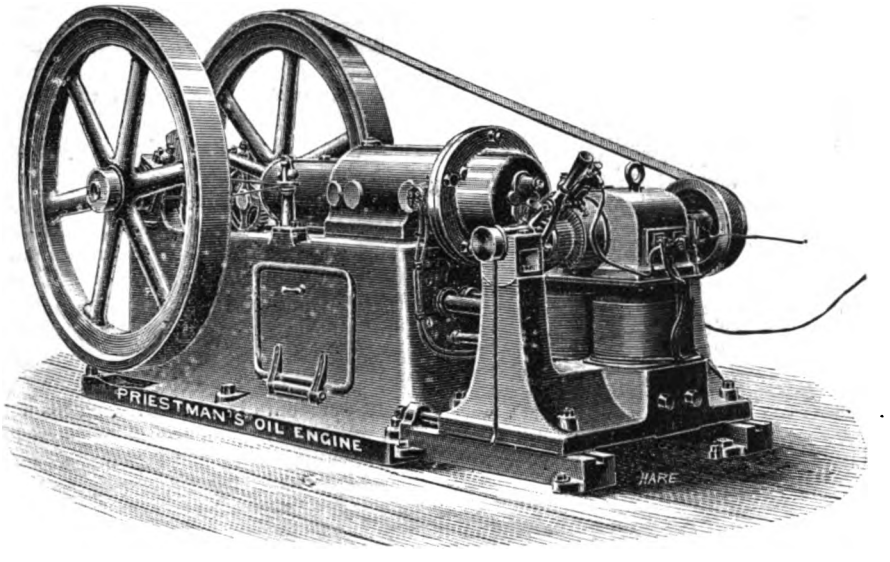
tance of 20,000 volts to be 26mm., and with a condenser of 15mm. to be 80mm., Herr Schneller is of opinion that with the 6,000 square metres presented by the line the striking distance will become something considerable.

Without following the author to this pessimistic conclusion, it may be safely said that the electric transmission by an overhead line of 300 H.P., at a pressure of 30,000 volts, and to a distance of over 100 miles, will not be without unexpected developments.

ELECTRIC LIGHTING BY PRIESTMAN OIL ENGINE.



Messrs. Priestman Bros. (Limited), of Hull, and 73A, Queen Victoria-street, London, E.C., have recently supplied to Mr. G. Aspland, of Boston, one of their 3 H.P. oil engines and Taunton dynamo, the latter made by Mr. F. M. Newton, of Taunton. The engine and dynamo are mounted upon a bogie, fitted with road wheels. The dynamo is driven direct from the flywheel of the engine at a speed of 1,300 revolutions, and supplies four arc lamps, with a current of six amperes, each at a pressure of 60 volts. All the wire leads to the lamps are attached to main cables by means of special brass clips, which can be detached at a moment's notice.

Messrs. Priestman Bros. (Limited) are now making oil engines from 1 H.P. to 25 H.P. A large number of engines have been supplied for electric lighting, orders having recently been executed, amongst others, for this purpose, for the Victorian and New South Wales Governments.

THE ANGLO-AMERICAN TELEGRAPH COMPANY AND THE PARIS-NEW YORK TELEGRAPH COMPANY.

The following is an account of the action between the Anglo-American Telegraph Company and the Paris and New York Telegraph Company, which was argued before the French Council of State in Paris, on Friday, the 1st inst. :—

The Council of State in Paris was occupied, on Friday last, with hearing the appeal of the Anglo-American Company from the adverse decision of the Council of Prefecture of the Seine on March 19, 1889, in the action of that Company against the Paris and New York Telegraph (P.Q.) Company. This action was first commenced in the Tribunal of Commerce of Paris early in 1887 for specific performance by the Paris and New York Company of the joint purse agreements made by them, in 1880 and 1882, with the Anglo-American, the Direct United States Cable, and the Western Union Companies, or, in the alternative, for damages for breach of those agreements.

After the agreement of 1880 had been in operation for six years, greatly to the advantage of the Paris and New York Company, the Mackay-Bennett combination (Commercial Cable Company) appeared to have obtained a preponderating influence on the French Company, and on December 31, 1886, the Managing Director of that Company abruptly gave notice to the Anglo-American and other Companies, parties to the agreements, that, in pursuance of a letter of the previous day from M. Granet, then Minister of Posts and Telegraphs, the Paris and New York Company put an end to the joint-purse agreements as being contrary to the terms of their concession from the French Government, which required the written consent of the Government to any such agreement, and which consent the Government had not given.

Count Dillon was then Managing Director of the Commercial Cable Company, and had previously held the same position in the Paris and New York Company, and it was alleged that the Minister's letter had been written at the instigation of one of those companies. It is certain that the French Company took no step to modify the Minister's requisition, or to obtain from him the written consent which was said to be necessary, and that on January 27, 1887, they made an agreement with the Commercial Cable Company.

On January 9, 1888, the Tribunal of Commerce gave judgment in the action in favour of the Anglo-American Company, requiring the Paris and New York Company to resume performance of the agreements, and awarding the Anglo-American Company heavy damages. The Paris and New York Company appealed to the Court of Appeal, and there for the first time objected to the jurisdiction of the Tribunal of Commerce, on the ground that, as the question arose under a Government concession, the interpretation of that concession, and of the Minister's letter, belonged to the administrative tribunals (the Council of the Prefecture of the Seine, with appeal to the Council of State). The Court of Appeal so far agreed in this view as to direct that the questions on the meaning and effect of the concession and of the Ministerial letter should be referred to the administrative tribunals, and reserved its own decision on the other matters in issue.

On March 19, 1889, the Council of the Prefecture decided in favour of the Paris and New York Company's contentions. From this decision the Anglo-American Company appealed to the Council of State. The case was argued at length on Friday, and the legal commissary of the Government having given his opinion on several grounds against the Paris and New York Company, the President of the Council, at 10 o'clock on the same night, pronounced judgment in favour of the Anglo-American Company, basing the decision of the Council on the ground that the Ministerial letter of December 30, 1886, was not an order to denounce or annul the agreements, but simply a notice to the Paris and New York Company to observe the conditions of their concession, and that this letter was no obstacle to their taking the necessary steps to obtain the express written consent of the Government to the agreements. The defendants were condemned to pay the costs.

This important judgment, although final on the main legal point, is not an end of the litigation. The case will now go back to the Court of Appeal to deal with the other matters, including the amount of damages to be paid by the defendants, which, at the date of the judgment of the Tribunal of Commerce, amounted to about £32,000. The damages payable after the notification of the first judgment were reserved by the Tribunal of Commerce for further consideration, and will now have to be fixed.

With respect to the written consent of the Government not having been originally obtained, it is explained that, in October, 1880, the late M. Pouyer-Quertier applied to M. Cochery, then Minister of Posts and Telegraphs, for his consent to the first agreement, and was informed by M. Cochery that the agreement, not being for an amalgamation or lease of the lines, did not require the consent of the Government. In consequence of this statement the agreement was put in force and acted upon for six years, with the results above stated.

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LEGAL INTELLIGENCE.

In Re the Electrical Engineering Corporation (Limited).

Upon the hearing of this petition, before Mr. Justice Kekewich, last Saturday, a question of importance arose in reference to the effect of the new procedure introduced by the Companies Winding up Act, 1890—namely, how far the Court, in the exercise of its discretion, will have regard to the existence of that procedure in considering whether a supervision order or a compulsory order should be made. The petitioners were the holders for value of a bill of exchange which had been accepted by the Company, and subsequently dishonoured at maturity. Previously to the presentation of the petition an order was made in a debenture-holder's action for the appointment of a receiver and manager of the Company's undertaking and property. It was stated that the debentures comprised the whole of the assets of the Company, including the uncalled capital. After the presentation of the petition the Company passed resolutions for a voluntary winding up. Mr. Marten, Q.C., and Mr. O. L. Clare, for the petitioners, asked for a compulsory order. Mr. Swinfen Eady and Mr. Le Fanu appeared for the Company.

Mr. JUSTICE KEKEWICH said the petitioners were the holders of a bill of exchange accepted by a mercantile firm, and not only were they told that they could not now have the only remedy which the law gave them, but they were deprived of that remedy because the mercantile firm, since the proceedings were commenced, had determined to wind up their own affairs in their own way. In the case as so stated there was no doubt some little hardship and some inconsistency with what were by many regarded as common law rights. This Company, which his lordship had referred to as a mercantile firm, had managed to get, somehow or other, £50,000, or, at all events, that was the amount of their capital supposed to be represented by cash. That was apparently all gone. Certainly there was none of it left to answer the petitioners' claim, and the Company had borrowed £20,000 on debentures, and were indebted to their creditors to an amount which the petitioners said was £20,000, and which the Company stated to be £12,000. The case, therefore, appeared to be one which deserved investigation by the official receiver, who under the new legislation looked into such cases. But the Court of Appeal had held that a resolution to wind up voluntarily might be passed after the presentation of the petition, so as to put a creditor who asked for a compulsory order to the necessity of proving that he would be prejudiced by the voluntary winding up; and the Court of Appeal further held, affirming the judgment of the present Lord Justice Kay, that, under circumstances similar to those which existed in the present case—where it was not shown that there had been any misapplication of moneys between the date from which a compulsory order would take effect and that when the voluntary winding up commenced—the creditor was not prejudiced by a supervision order being made. In that case Lord Justice Kay said that he wished to prevent costs which were not positively necessary, and pointed out that if a supervision order were made any person aggrieved might apply to the Court in reference to the winding up. That view found favour with the Court of Appeal, and was applicable to the present case. No doubt a petitioner so endeavouring to interfere with the voluntary winding up was in a position of considerable difficulty, and had to act at a risk, which was a real one, as to costs; but still he had that remedy. To what extent would the petitioners be injured? An important circumstance to be regarded was this—that, as was admitted, the debentures covered everything belonging to the Company, even (according to the modern form of debenture) the uncalled capital. There must, so far as could be seen, be some uncalled capital which would go to the debenture-holders; but apparently there would be absolutely nothing coming to the petitioners. The only advantage, therefore, of a compulsory order would be that which would be gained by the public if these matters were investigated. Great as that advantage to the public might be, his lordship could not regard it as such an advantage to the petitioners that by not having it they would be prejudiced within the meaning of Section 145 of the Companies Act, 1862. On that ground a supervision order must now be made.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *April* 25, 1891.

The Electrical Production of Aluminium.—At the last meeting of the American Institute of Electrical Engineers an interesting Paper was read on "The Electrical Production of Aluminium," by A. S. Brown. There are now no less than three companies in the United States actively engaged in this work. The Cowles Company, whose process is as well known in England as here; the Pittsburgh Reduction Company, working under Hall's patents; and, finally, a company at Booneton, N.J., operating the Heroult process. Mr. Brown's Paper was largely devoted to the description of this last plant, and the results there obtained. Cheap aluminium is now an accomplished fact in this country, but the metal does not appear to have made its way into anything like extensive use, probably owing to the absence of any alloys, except that with silver, that possess at once lightness and particularly valuable mechanical properties. At the same meeting of the Institute were produced some extraordinary lucubrations by Mr. N. D. C. Hodges on the subject of protection from lightning. The author formulated the astounding proposition that the best lightning protector is one so small as to be vaporised by the discharge.

Electric Traction in Brooklyn.—A vigorous discussion is now going on with respect to the introduction of the trolley system of electric traction in the City of Brooklyn. Its advocates are very earnest in their efforts to secure permission for the erection of overhead lines, but the municipal authorities do not seem to see it in that light. It is a singular fact that in spite of every effort to put the situation in its true light, the public persistently refuse to recognise the fact that there is a distinction between an electric light circuit and an electric railway circuit as regards danger to human life. There is a deep-rooted opinion that any electrical current, except that proceeding from telegraph offices and from Edison stations, is morally certain to kill anybody who has the temerity to look hard at it, and no amount of popular education seems to produce the slightest effect in correcting this impression. Several recent accidents have created additional excitement, and, as ill-luck would have it, a couple of horses were recently killed by a telegraph wire that had fallen across an arc light circuit; consequently the daily Press can find no terms too severe for appropriate denunciation of the trolley system.

The Bell Telephone Company.—A plentiful crop of rumours are flying about as to the intentions of the Bell Telephone Company. It is stated on pretty good authority that that organisation owns an interference between Berliner and Edison, with the broad principle of the microphone as its essential feature, and proposes to settle the interference and secure a patent before its present legal rights are extinguished in 1893.

Storage Battery Traction.—The storage battery cars in New York have not yet resumed running. No one seems to be able to say definitely what is likely to become of them. Yet, in spite of repeated failures, the public sentiment in favour of storage battery traction is so strong that a successful effort would be amply rewarded. Although hope has been long deferred, there is a general feeling that the storage battery is not by any means dead.

PARIS NOTES.

(FROM OUR OWN CORRESPONDENT.)

PARIS, *May* 4, 1891.

The central station serving the Place Clichy sector was recently inaugurated in the presence of a large gathering of scientific and political notabilities, amongst whom were the Minister of Commerce and Industry, the Minister of Public Works, M. Alphand, Director of Works for Paris; M. Hult, Sub-Director; General Menabrea, M. le Royer, President of the Senate; M. Poubelle, Prefect of the Seine, and everyone of any importance in the electrical world. The honours were done by MM. Siegfried, Koechlin, Blech, Heilmann, Pirani, Soubeyran. M. Alphand started one of the 500 H.P. engines. The two following days M. Pirani gave some lectures to the engineers of the Ecoles Polytechniques et des Arts et Manufactures on the advantages of the 5-wire 440 volt system of distribution as compared with others. This 3,000 H.P. station is the first of its kind in France.

The Conseil Municipal has just authorised its officials to enter into negotiations with the Sociétés Edison, Popp, de la Transmission, and Secteur Place Clichy with respect to the renewal of the contracts for the lighting of the Grands Boulevards for 10 years at 40 centimes for 10 ampere arcs, and 57 centimes for 15 ampere arcs. The expenditure will be 348,000 francs, as against 121,000 francs for gas, but the light will be five times as great.

The result of the Municipal electric meter competition will shortly be announced. The tests of the continuous current meters are completed, and the alternate-current meters will be disposed of in a few days. In spite of the opposition of the inventors, the Committee have done well to spread the tests over a lengthy period, for long continued working has shown up many little defects not observable at the start. However, the competition will only have ascertained the condition of the electricity meter art twelve months ago, and not its present state of progress, for several meters have been much modified since the competition commenced.

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The Tudor Accumulator Company has just established a factory at Lille, in order to be in a position to compete more easily with the Société Français des Accumulateurs E.P.S., which has amalgamated with the Société l'Electrique, of Brussels, which exploits the Julien accumulator. The Société pour le Travail Electrique des Métaux, owning the Laurent-Cély patent (see *The Electrician*, Vol. XXV., May 30, 1890, p. 82) has modified its style of plate so as to obtain a better hold on the active material. Its already large factory is about to be still further enlarged.

CORRESPONDENCE.

ETHER THEORY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The increased interest which certain researches and oracular utterances and writings of the past two or three years has aroused in the hypothetical philosophy of an all-pervading ether is sufficient excuse, I think, for asking a corner in your esteemed journal for some fancies of mine, which seem to have a plausible bearing upon electrical theory in those profounder depths to which the said means have largely contributed to open out the way. Starting from the postulate, which is strengthening into an axiom with every stride of research, that a surrounding medium or ether, most probably identical with that assumed in the case of radiant light and heat, is responsible for the propagation of electric energy, I wish to suggest a mode of regarding this ether and its properties which apparently has been hitherto neglected, and which seems to me to remove many difficulties from the way. What these difficulties are Sir William Thomson, Prof. Lodge, and other well-known workers in this field have of late years been showing us very clearly indeed. And that they are very real and tangible difficulties is evident from the fact that the former, even while formulating perhaps at once the completest and most elegant hypothesis of etheric structure ever advanced, acknowledged that he was still very far from satisfied; and from the candid way in which Prof. Lodge has admitted that he is yet unable to dispense with the idea of two electricities in certain sections of electrical science.

Now, the point I have to advance is that the ether being by hypothesis the disperser of energy, or, in other words, the medium upon which all potentials react in their efforts towards neutrality, the full significance of the theorem here presumed should be more thoroughly kept in view, and our further reasonings educed from it as a basis.

At present, however, the tendency of thought seems to be firmly set towards a conception of the ether as a kind of merely virgin menstruum, undisturbed and unacted upon by any impressed forces other than those immediately under consideration.

Obviously, this is too narrow and simple a view. For, by the actual nature of the fundamental hypothesis, this ether, select it from whatever region of space we will, is ever subject to a constant succession of energised impulses, so that it is illogical to conceive it as existent under any other condition. Hence, except that it can be shown that simultaneously impressed forces may not in the mean result interfere with a distinctive propagation and manifestation of each, much of our present physical theory must fall to the ground. Happily, however, the success of mathematical reasoning proves clearly enough that the presence of many impressed forces may be ignored in calculating for mean results; but the principle is not thereby established for all cases, and, in fact, the aspect of a problem may be entirely changed by ignoring these bye-influences, as I may call them.

Take, as instance, the kinetic theory of gases. The explanation of gaseous phenomena by this theory presumes the possession by the ether of a property which is otherwise not so requisite—a property which is open to the objection of being inconceivable—that of being absolutely devoid of inertia. It must offer no resistance to passage of bodies through it, else it is impossible to conceive the perpetual retention by the gaseous molecule of its primary impulse of energy. This practically inconceivable state of things is what the conception of a *still* ether leads us to in this connection. On the other hand, note how simply the less artificial conception of an *agitated* ether meets the case. By the purest natural logic it leads up to a very plausible hypothesis that the gaseous molecules *derive* and continually *renew* their kinetic energy *from* the ether agitation. A similar action is, indeed, assumed in heat theory, but it is given only a vague and partial significance. But I must not enlarge further upon this here, though it is a rich and fascinating theme.

Coming particularly and briefly to the bearing upon electrical theory, I shall, to save preliminary explanation, assume much that has lately been advanced in this direction. Granting, then, that the ether is the medium of transmission of electrical energy, we have to determine whether the consideration of an agitated, as opposed to the ordinary, acceptation of a still ether, can throw any light upon the crucial question why electrical energy is selective of a path, and a closed path? I believe it can, and rather successfully. For instance, consider a metal conductor in the agitated ether. It is continually impinged upon by the ether waves traversing the surrounding space, which, being mostly reflected, set up around the conductor a series of stationary waves or alternating succession of nodes and loops. Assume this conductor to connect a source of positive potential with a source of negative potential. The still ether particles situate in the nodes around the conductor will be in a comparatively favourable state to receive and transmit impulses of energy, for forces can act upon them without being modified by the reaction due to forces of which they may be already under the influence.

Hence we have a tendency for the energy to be transmitted along the conductor. Of course it is not asserted that there exist actually fixed nodes; the point is that there is produced a damping or reducing of the ether vibration in the vicinity of reflecting surfaces. In formulating the hypothesis we set up two postulates: first, that the most agitated ether is the best insulator of energy; second, still ether is the best disperser of energy. Also it is an obvious deduction therefrom that substances with high reflective powers should have high electrical conductivity. This is practically true in fact, for the orders of the coefficients agree fairly well, considering the difficulties attendant upon exact determinations of reflective or absorptive powers.

I place the above before your readers, hopeful of correction where I may be in error.—Yours, &c., J. WHITCHER.

TWISTED TELEPHONE LINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Bennett's views on this question, I am afraid, differ from those of many other telephone engineers in this country. After describing the merits of the cross system he summarises the drawbacks of the twist system under five heads. I think if these drawbacks are carefully examined it will be found that they are to a large extent imaginary, or apply in a greater degree to the system he advocates.

Dealing with them in the order given, we have:—

1. *Greater first cost of the Twist System.*—To carry out the cross system it is necessary to have a number of extra insulators, special brackets to carry two insulators on one arm, extra wire for the frequent terminations and cross-connections; also, extra labour is necessary to fix all these extra fittings and cross-connections. On the other hand, with the twist method a little additional labour is required in running the wires, and with men accustomed to the work this additional amount is very slight. This, I think, rather indicates that the *crossed* method involves the *greater* first cost, and especially so when the number of metallic circuits on a line is large.

2. *Unsightliness of the Twist System.*—This, so far as the public are concerned, is unnoticeable, and, to the technical man, it is purely a question of sentiment.

3. *Greater liability to faults of the Twist Plan.*—Having in each system a similar distance between the arms, and, given the same amount of care in regulating in each case, I fail to see why two wires are more liable to get in contact when crossing each other than when they hang in the same vertical plane, as in each case there is the same vertical distance between them.

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4. *Greater difficulty in finding faults in the Twist Method.*—This, I think, is entirely imaginary, as any man accustomed to the system can easily detect a fault by noticing the movement of the apparent cross in the wires as he walks along.

5. *Re-arrangement of Routes.*—This objection applies far more to the crossed method than to the twist. Suppose, that in arranging, the number of spans in any section is altered, the worst that can happen with the twist plan is that each two circuits are reversed—no very difficult matter to overcome; whereas an alteration of the number of spans in a section on the crossed system may upset the balance of the whole line, and involve an extensive redistribution of crossing points.

In conclusion, I must say that I feel very doubtful as to whether a straight ten mile loop will kill *all* overhearing and telegraphic induction; also that I did *not* know that two single lines could be run on the same arm for a mile without experiencing any cross-talk; in fact, if these lines are pretty free from other noise, the cross-talk will be quite appreciable.—Yours, &c.,

J. W. ULLETT.

May 5, 1891.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My attention having been directed to the article on Twisted Telephone Lines in your issue of the 17th ult., and to Mr. A. R. Bennett's remarks thereon in your issue of the 1st inst., I should feel obliged if you will allow me to correct the impression conveyed with respect to the points at which the wires on the Midland used for telephone purposes are crossed. Such wires as have been erected in this manner have been usually crossed at every fourth pole, but it will be evident that the crossing need not, as pointed out by Mr. Bennett, be at every fourth, much less at *every* pole.

The position of the crossings should, in point of fact, be governed, as it appears to me, by the neighbouring wires. If we take the case of two telephone wires erected on poles carrying one other wire, this other wire being used, say, for a Wheatstone, it would only be necessary to cut and cross the telephone wires, say, midway of their entire length, in order to counteract the influence upon them by the Wheatstone wire.

Again, suppose a similar wire passing along the poles carrying telephone wires for a short distance only, it would then be necessary to cut and cross the telephone wires at the point where the interrupting wire parted from the telephone wires, and at a point midway in the section traversed by the telephone wires as well as by the Wheatstone wire.

Of course, where you have many wires from which induction may arise, it is desirable to lay down a general governing principle such as shall meet the general conditions to be met with, and crossing the wires at every fourth pole certainly ought to meet this condition.

Some reference is made to "interruptions" where wires are crossed in this manner. Although we have had experience of such crossed wires for many years, I cannot call to mind any interruptions which have occurred; nor do I think the system likely to give rise to interruptions. The cross connections are made by open wires from one wire to the other, an insulator being employed between the two connections in order to keep them from contact with the pole where such is found necessary.—Yours, &c.,

W. LANGDON.

Midland Railway Telegraph Department,
Superintendent's Office, Derby,
May 4, 1891.

WIRING SYSTEMS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: To many of us students who sat for the City Guilds' Exam., on Wednesday, the 29th ult., the question as to what were series-multiple and multiple-series, and also series-parallel and parallel-series, much perplexed us.

Again, the term multiple-arc is to me intensely vague. Could not the word arc be entirely abolished, and for multiple substitute parallel? Why do not electricians confine themselves to simply the terms series and parallel, as I think every ordinary process of wiring, &c., can be explained by their use alone.

On page 31 of the current edition of "Electric Light Fitting," by Urquhart, the following diagram occurs:—

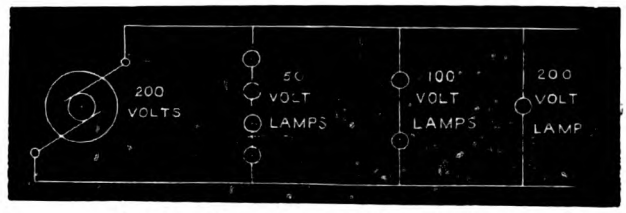

FIG. 44.—Diagram of Series-Multiple Circuit

And on page 134 (*i.b.*):—

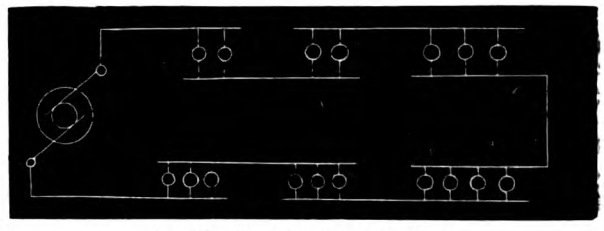

FIG. 47.—Multiple-Series Method.

Are these correct? I am of opinion that Fig. 44 should have been termed the parallel-series method, and Fig. 47 series-parallel.

Mr. Urquhart, in his preface, addresses himself to "intelligent men already engaged in the work of electric lighting, or training for it," and goes on to say, "he does not attempt to teach trained electrical engineers any part of their business, as these gentlemen need no instruction from books."—Yours, &c.,

A. FREYER EVANS.

Newport, Mon.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

"THE ELECTRICIAN"

ELECTRICAL TRADES' DIRECTORY & HANDBOOK for 1891.

The 1891 edition of our well-known Directory and Handbook is ready, price 5s., postage extra. The book consists of over 900 pages, and has entailed this year a heavy amount of work. The HANDBOOK DIVISION contains a mass of most useful information. The DIRECTORY DIVISION consists of 430 pages, and contains a very carefully compiled Alphabetical and Classified List of Firms and Persons engaged in the Electrical and Allied Trades in all parts of the world. This Division has been corrected up to date, and the book is thoroughly reliable, the very numerous changes which take place at the beginning of the year being incorporated. By the aid of this Directory, makers of Electrical Machinery, Apparatus, Instruments, Fittings, Sundries, Novelties, and other goods, may safely communicate direct with probable customers without the annoyance and great expense consequent upon using books which are mere lists of Members of Scientific Societies repeated again and again. The Colonial and Foreign Division of this Directory will be found extensive and reliable. *Orders should be forwarded at once.*

In the course of a few weeks "The Electrician" Company will publish "THE ELECTRICIAN" PRIMERS in two volumes, price per volume 2s. paper covers, 2s. 6d. cloth.

THE FRANKFORT EXHIBITION.—As announced in our advertisement pages, the Frankfort Electrical Exhibition will open on May 16th, and it will interest many of our readers to know that the Great Eastern Railway Company are making arrangements for the comfort of intending visitors to Frankfort. The Continental booking-office at Liverpool-street station will be open daily from 9:30 a.m. till 8 p.m., and an attendant accompanies the train as far as Harwich, who will give passengers any information and assistance they may require. The Company's passenger steamers (11 in number) are all lighted by electricity. Applications for deck cabins and saloon berths on the Company's steamers should be addressed to Captain Howard, of Parkestone-quay, Harwich.

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Special facilities are offered to passengers from the North, the Midland counties, and the North-West of England over the Great Eastern Company's joint lines. The Company issue an exhaustive time-table giving a map showing the route and full detailed particulars. Negotiations are in progress for the running of excursion trains to Frankfort from all parts of Germany at cheap fares while the exhibition is open.

MESSRS. CHRISTY BROTHERS.—The firm of Christy, Son, and Norris, electrical engineers, of Chelmsford, has dissolved partnership, and the business will be carried on in future under the style of Christy Brothers.

PARTNERSHIP NOTICE.—We are informed that Mr. Gastrill Wilkins, of the Wire Rope Works, High-street, Wapping, has taken into partnership Mr. S. H. Hudston, for many years with Messrs. Richard Johnson and Nephew; and that the wire-rope manufacturing business will be continued under the style of Messrs. Wilkins and Company.

MESSRS. E. L. BERRY, HARRISON, AND COMPANY.—Mr. E. L. Berry informs us that he has entered into partnership with Mr. F. Harrison, of Liverpool, and that they will carry on business under the above style at Lyric-chambers, Whitcomb-street, W.

THE CAMBRIDGE SCIENTIFIC INSTRUMENT COMPANY.—We have received the illustrated catalogue of the manufactures of this firm. The excellence of the workmanship, and the careful scientific supervision of the design, of their instruments is well known. Their speciality is in apparatus for physiological research, but their list contains a considerable number of electrical instruments and includes "quartz fibres." We understand that this Company are engaged in designing some apparatus for the Electrical Standards Committee of the Board of Trade.

THE LIGHTING OF LAMBTON CASTLE.—The Earl of Durham has decided to thoroughly reorganise the electric-lighting arrangements at Lambton Castle. The existing machinery has been found to be of insufficient power to light the Castle satisfactorily, and an entirely new electric generating plant—comprising two "Cornish" boilers, each of 25 nominal H.P., and two "Parsons" steam turbines and dynamos of the new improved type, with automatic expansion, each capable of supplying 32 kilo-watts, is to be erected by Mr. A. A. Campbell Swinton.

SHIP LIGHTING.—Messrs. J. D. F. Andrews & Co. have installed the electric light on the new Japanese Royal Mail steamer "Jenkia Maru," built by Messrs. Napier, Shanks, and Bell. Messrs. Andrews' concentric wiring system has been adopted. The installation is for 150 16 c.p. lamps. The dynamo is driven direct by an open vertical engine with Pickering governor.

WIRE TABLES.—Messrs. W. F. Dennis and Company are issuing a new edition of their tables relating to the various gauges employed in this country and on the Continent. A useful feature is a table showing the breaking strain for iron and steel wire of various brands and of the Standard Wire Gauge.

MR. WILSON HARTNELL.—We learn that this gentleman, who has recently opened at 11, Queen Victoria-street, E.C., has been appointed by Messrs. Cole, Marchent, and Morley, engineers, of Bradford, their agent for all classes of general engineering, oil mill machinery, &c. Mr. Hartnell has also been appointed agent to Messrs. James Lee and Sons, leather belting manufacturers, of Hipperholme, near Halifax.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

April 20, 1891.

6,767. W. LUCAS and T. A. GARRETT. London. Improved means for the production of ozone electrically.

6,773. L. von ORTH. London. Improvements in apparatus for signalling time, and for regulating clocks by electricity.

6,774. H. de REUTER and E. E. H. GOWER. London. Improvements relating to electric conductors.

6,782. H. L. CALLENDER. London. Improvements in dynamo electric machines and electric motors.

6,793. P. C. E. CHAMPION. London. The application of electricity for the production of pyrotechnic and other similar effects and apparatus therefor.

April 21, 1891.

6,831. A. L. PARCELLE. London. Improvements in dynamo electric machines.

6,846. S. R. LINVILLE. London. Improvements in printing telegraphs.

6,847. S. R. LINVILLE and L. F. HETHNANSPERGER. London. Improvements in printing telegraphs.

6,870. J. W. T. CADETT. London. Improvements in electric motors.

6,881. J. E. WALCOTT. London. An improved method of and apparatus for covering electric wires.

6,890. F. B. ASPINALL. London. Improvements in and connected with electric locks.

SPECIFICATIONS PUBLISHED.

1890.

8,474. MCEVOY. Electrical switches. (Price 8d.)

8,534. DE BENARDOS and Others. Secondary batteries. (Price 4d.)

8,720. WALTER. Electro-magnetic railway brake.

9,602. SIEMENS BROTHERS & Co., LIMITED (Siemens and Halske). Distributing electrical energy. (Price 8d.)

12,169. DESRUELLES and CHAUVIN. Measuring electrical energy. (Price 8d.)

20,115. BARRETT, C. A. & A. Coin freed dynamo-meters. (Price 8d.)

1891.

3,191. DOLIVO-DOBROWOLSKY and Others. Distributing electricity. (Price 11d.)

WEST COAST OF AMERICA TELEGRAPH COMPANY (LIMITED.)

The following report of the Directors of this Company arrived too late for classification:—

The balance sheet and revenue account for the year ending December 31, 1890, show a gross income of this Company of £65,323 15s. 4d., against £84,457. 13s. 1d. for the year ending December 31, 1889. The addition of £517. 10s. 3d. brought forward from the previous year makes a total of £65,841. 5s. 7d., and, deducting from this the debenture interest and all other charges, as well as the interim dividend of 3s. per share paid in July last, there remains the sum of £22,195. 12s. 11d. Out of this amount the Directors have transferred £16,000 to the reserve fund, bringing it up to £80,000, written off £1,000 from the value of the repairing steamer "Retriever," and now recommend the distribution to the shareholders of a final dividend for the year 1890 of 2s. per share, payable on the 20th inst., leaving £2,195. 12s. 11d. to be carried forward.

The cable with which the Central and South American Telegraph Company intends to compete with your line has been laid, but is not yet working in its entire length, owing to the revolution which has broken out in Chili.

In accordance with what was suggested at the extraordinary general meeting of shareholders, held on September 1st last, negotiations have been commenced with the object of strengthening the position of the Company, and opening for it a source of revenue not otherwise obtainable.

The Directors look upon the present as a period of transition, but expect that these negotiations will lead to a satisfactory result; meanwhile they do not consider it prudent to make a larger division of profits than that recommended in this report.

During the Chilian Revolution, which broke out in January last, and unfortunately, still continues, the cables of the Company have been cut by both Government and Opposition forces; the Company has, however, received partial compensation for the interference with traffic. The repairing steamer is in readiness to connect the sections cut as soon as hostilities come to an end.

Mr. Henry Roberts and Mr. Alfred Marshall are the Directors retiring in rotation; both are eligible and offer themselves for re-election. The auditor, Mr. J. Weise, of Messrs. Turquand, Youngs, Weise, Bishop and Clarke, retires, and is eligible for re-election.

COMPANIES' MEETINGS & REPORTS.

Brazilian Submarine Telegraph Company (Limited).

The thirty-fifth ordinary general meeting of the shareholders of the Brazilian Submarine Telegraph Company (Limited) was held at Winchester House, Old Broad-street, on Wednesday, under the presidency of Sir James Anderson.

The SECRETARY (Mr. Richard Collett) having read the notice calling the meeting and the minutes of the last meeting (which were signed by the Chairman as correct), the report of the Directors was taken as read.

The CHAIRMAN then said: I will ask your leave, before proceeding to the financial part of the report, to refer to paragraphs 4 and 6, in which you will find that we have lost from among us our noble Chairman, Lord Monck, and Sir Thomas Fairbairn. Their City engagements became too onerous for them, mainly, I am sorry to say, on account of prolonged ill-health, and they desire to be relieved of these obligations as much as possible. I am sure you will join with me in expressing your wishes to these gentlemen that the repose they are now seeking will restore their health, and that they will have that calm and comfort which they desire, and which, I am sure, they thoroughly deserve. You see also, in paragraph 6, that we have filled these vacancies by the election of two perfectly unexceptionable gentlemen, namely, Lord Sackville Cecil and Mr. J. Denison Pender, who have for some years been among us, acquiring that knowledge of our ramifications and negotiations which, I am sure, are far more numerous than the shareholders are aware of. I am glad to find that we can meet with young gentlemen of experience to take the places of those of us who are going very fast behind the scenes. Those of you who are watching the passing away of the senior members of these Boards must be struck with the great number who are leaving us from one cause and another—mostly bad health and death—and how necessary

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it is that we should fill up their places by young men with heads on their shoulders, and with some "go" in them to meet the contingencies that are fast arising. I propose, in the observations which I am about to address to you now, to make some remarks indicating the necessity for a strong Board. I am not going to alarm you, for I am not alarmed myself; nor do I take a despairing view of what is going on. It would, however, I think, be wrong if I were not to say that we have arrived at a period in our history which may be termed a turning-point, and, perhaps a crisis. For all that, I am not anxious. I believe that we can give as good as we get, and those who are making opposition lines will find that they are opposing two companies who are well up in their work. If you look at that map you will see what I mean. A line has been made from Charillos, on the west coast of America, to Valparaiso, which is meant to oppose the West Coast of America line, and, if those connected with it could get all they desire, they will come across the Andes to Buenos Ayres, and get into our region. The Brazilian Government have granted a concession for a cable from Pernambuco to Senegal. That is a project which has been talked of for 16 years, and we are not alarmed about it. There is, however, a line that is being made which has some significance. It is laid between Cuba and Dutch Guiana at present, and they mean to connect Brazil and North America. We do not, however, stand afraid of that either. Our Company has duplicated lines, and our partners, the Western and Brazilian, are duplicating their cables also. We are duplicated all the way from England to Pernambuco, and the Western and Brazilian are now duplicating their line from Pernambuco to Santos. If we duplicate as we are doing, and have the duplex applied to our cables, we are very strong. It has been the policy of this Board since the inception of the Company some 18 years ago to lay by a large reserve. Fortunately for us, our reserve has reached a point at which we have duplicated the whole system without adding to our capital, excepting in a small way, by Debentures which are fast being paid off. Besides that, we have in our bank in securities upwards of £400,000 as a substantial addition to a growing reserve. Now, you would naturally expect when we are having such fine traffics—largely owing, I daresay, to the late crisis in Argentina and the war in Chili—that we should give you a larger bonus, and we shall have to consider the question of bonus prior to our next meeting; but I will urge you to be satisfied with what I call a good dividend, and to encourage your Directors to amass as much reserve as possible while times are good, because, inevitably, when these lines are laid, they can have no other policy but to reduce the tariff, and that, of course, will reduce our dividend—at all events, will reduce our power of laying by a good reserve if we keep up a good dividend. We must, therefore, make hay while the sun shines; and such is the policy of your Directors, which you will, no doubt, support. Having, as I said, duplicated our lines and when we have duplexed them, we shall be quite in a position to meet all comers whenever they try to make any experiments with reduced tariffs. We can come down as soon as they can. Possibly we might have come down sooner but for these lines threatening us. We must lay by what money we can, and pay you as good a dividend as possible while we have the chance. So far as our calculations go, taking the worst view of it, even with these competing lines made and the tariff reduced, I do not despair of our paying a good dividend and making a fair addition to the reserve. That is a good position to be in. With a large reserve of carrying force, a large reserve of sovereigns at your bank, and with the power of extending your system more, perhaps, than our opponents are aware of, into some chinks of their own armour, which they are not thinking of now, you must, I think, see that this is a position which makes our Company somewhat invulnerable. At all events, we have no necessity to be afraid of our opponents. Naturally, we cannot hope to keep a monopoly for ever; but we possess all the elements which make telegraphy a success, in my opinion—that is, having duplicate cables, a large reserve of carrying force, and a reserve at our bankers'; and with a trained staff of telegraphists, ensuring accuracy and speed, I think we have as good a chance of continuing our existence profitably as any Company that can be imagined. I do not propose to describe what we think we can do by-and-by by way of extensions, but we are not going to be idle. I shall now refer to some points in the financial part of the report. Abstract A, dealing with the general expenses in London, is practically without any feature calling for remark. Abstract B shows an increase of expenses of £1,092, mainly due to the following items:—A new sanatorium at St. Vincent, costing £600. We are suffering a great deal at our different stations from the want of good sanatoriums and the want of sanitary arrangements, and we think it is our duty as Directors to keep our young men alive and give them what accommodation we can to compensate them for spending their lives at these stations. We have spent £276 at Madeira, on improving the sanitary arrangements. Mr. Fuller told me this morning that Madeira is the most unhealthy station we have, though people go there to recover their health. We have spent £100 at Pernambuco, mostly on replacing timber beams in the staff quarters. On new and spare instruments, on account of the increase of traffic, we have expended £336, and we have made some increase to our staff to deal with the traffic, which increased by 16,000 messages last year. In the revenue account there is an item of £907 for legal expenses. This has arisen from a question of Brazilian law differing from English law, and the outcome of a transfer of shares under a power of attorney given by a shareholder in Brazil. We were advised to contest the action brought against us, and we have been contesting it since 1885. Subsequently the plaintiff sought a compromise, and, having regard to the uncertainty of the law and the greatly increased cost of continuing the action, our solicitor urged us to agree to a compromise. That item has, therefore, been met, and it is better to have done so than to have gone on building up legal expenses. In substance, then, gentlemen, our revenue has increased by £22,244; our messages from all sources by 16,000, and our expenses by £1,093. Mr. Dawes (our solicitor) reminds me that this item of legal expenses, amounting to £907, includes compromise, and was not all legal expenses. In paragraph 7 of the report we refer to the picking up of our cable off Madeira, and I think it only right to tell you—and I give credit for the fact to our men at Madeira—that the cable was repaired by the staff with local resources. The cable that was picked up by the Telegraph Construction and Maintenance Company's ss. "Scotia," was 18 years old, but after they got on to smooth bottom it was found to be as good as when it was laid. I think I have now referred to all the main points in the report, and I have held out some warning—not as a threat, but only as showing you the necessity of husbanding our resources, and not paying away too much until we see what we can do. I think I have also shown you that our rivals have their work before them. With these observations I now move:—

"*That the report of the Directors and the accounts to December 31st, 1890, now submitted, be approved and adopted.*"

The Hon. W. ST. JOHN F. BRODRICK, M.P.: I have much pleasure in seconding the resolution.

The CHAIRMAN expressed his readiness to answer any question; and, in replying to Mr. Newman (who referred to the item of £1,835 for depreciation in the value of the stock of spare cable), stated that after a cable had been in tanks and been turned over two or three times it depreciated. It, however, came in afterwards for repairs, and would be put in at the reduced cost. He then put the resolution, which was unanimously agreed to.

On the motion of Mr. W. T. ROUGHTON, seconded by Mr. T. M. NEWMAN, a cordial vote of thanks was passed to the Chairman and Directors.

The CHAIRMAN briefly acknowledged the vote, and the proceedings then terminated.

Great Northern Telegraph Company of Copenhagen.

The following shows the working account of this Company for the year 1890:—

	£	s.	d.	£	s.	d.
RECEIPTS.						
Balance on the 31st December, 1889				46,722	5	10
Traffic receipts	291,517	0	10			
Less loss on exchange	10,605	7	10			
				280,911	13	0
Interest				21,327	0	9
Sundries				6,422	3	6
				£355,383	3	1
EXPENSES.						
Salaries and wages				39,686	19	1
Expenses of Stations, Offices and Agencies				8,721	18	9
Ordinary supervision and maintenance of the sea and land lines, and repairing steamers "H. C. Oersted" and "Store Nordiske"				13,375	19	9
Instruments and cells				2,860	13	3
Maintenance of Company's buildings				454	9	9
Travelling expenses				585	17	5
Bank Commission, &c.				3,564	7	10
Sundries				305	10	2
Total Expenses				69,555	16	0
Five per cent. interest on debentures	12,500	0	0			
Amortization of 250 debentures	25,000	0	0			
				37,500	0	0
				107,055	16	0
The Board propose to distribute the balance as follows:—						
Reserve and renewal fund				66,666	13	4
Pension Fund of the staff				2,777	15	7
Remuneration to the board of directors				1,500	0	0
Interim dividends already paid				75,000	0	0
Proposed final dividend				54,166	13	4
Balance carried forward				48,216	4	10
				£355,383	3	1

The following is an abridged report of the proceedings at the general meeting held at Copenhagen on the 25th of April, 1891; F. Zahle, Esq., presiding.

The CHAIRMAN of the Company, C. F. Tietgen, Esq., in rendering an account of the working during the year 1890, referred to

The Company's Cables, which, he said, had been subject to about the same number of interruptions as during the previous year, viz., 27 in all; 14 on the European and 13 on the Far East Cables. The Company's cable steamers had, in consequence, been fully employed; in fact, the "H. C. Oersted" had been on active service for 166 days, and the "Store Nordiske" for 163 days, of which latter, however, 27 days had been for account of others. The cables which had suffered most from these interruptions were the North Sea cables, connecting Great Britain and France with Scandinavia.

New Cables.—Having regard to the numerous interruptions, the Company had every reason to congratulate itself upon the decision arrived at in 1890, to lay a new direct cable between England and Sweden, and also a second cable between France and Denmark. Although there were other business matters which had required urgent attention, nothing had been left undone to accelerate the realisation of these projects. As under the existing agreements with the British and Swedish Governments only a few minor points had to be settled, the laying of the new English-Swedish cable had already been accomplished in November last. The cable, which was 509 nautical miles long, and connected Newbiggin-on-the-Sea with

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Gothenburg in Sweden, had been manufactured and laid by the Telegraph Construction and Maintenance Company, Limited, of London, who had carried out the work very successfully and to the entire satisfaction of the Company. The new line was opened for traffic on the 23rd November last, and had been working very satisfactorily up to the present. The negotiations with the Danish, and especially with the French Governments, relating to the laying of the new cable between Calais and Fanoe in Denmark, had been of a somewhat more protracted nature, owing to the necessity of applying for a prolongation, and to some extent modification, of the existing Conventions. The new Convention granted by France, by which the privileges accorded to the Company had been prolonged until the 1st January, 1916, had actually been signed on the 1st October last. As, however, the sanction of the French Chambers had not been obtained till very recently, the Company had reluctantly been obliged to postpone this important undertaking until the current year. Although the delay was to be regretted, still it had this advantage, that the cost of the new cables could be spread over two financial years, and the investments already made on account of the reserve fund left intact.

Sale of portion of the Korea Cable.—Some time ago an agreement had been concluded with the Japanese Government, by which the length of the Company's cables in the Far East would be slightly reduced. By this agreement, two short lengths of cable (57 nautical miles in all), laid by the Company in 1884 between the Japanese Islands of Kiusiu, Iki, and Tsushima, had been transferred to the Japanese Government, who were anxious to add them to their internal telegraph system. Although the Company would have preferred to retain the ownership of these cables, which formed an integrant portion of the line between Japan and Korea, they had ultimately yielded to the wishes of the Japanese Government, who had always given the Company very marked proofs of sympathy and goodwill.

New Premises in Copenhagen.—The building of the Company's new offices in Copenhagen had made so much progress that they were expected to be ready for occupation before the end of the year.

The Traffic Receipts had amounted to about £280,000. which was a higher figure than had been reached in any previous year. This was principally due to the temporary rise in the value of silver, which had enabled the Company to effect their remittances from the Far East at exceptional rates of exchange. But even apart from this the net profits had exceeded those of any previous year.

International Telegraph Conference at Paris.—The great event of the year had been the International Telegraph Conference, which was held at Paris from the 15th May to the 21st June last year, when the European tariffs had been revised, and fixed for a period of five years from the 1st July, 1891. The Company, which had, as usual, been represented by the Managing Director, Captain E. Suenson, had agreed to participate in some very considerable tariff reductions. Thus, the rates between Great Britain on the one side and Denmark and Norway on the other, would be reduced from 4d. to 3½d. a word, between Great Britain and Sweden from 5d. to 4d., and between Great Britain and Russia from 6½d. to 5½d., &c. That the Company could meet these and similar tariff reductions with comparative equanimity, was principally due to the prudent financial policy which they had pursued for years, in applying a considerable portion of the receipts to an extraordinary amortization of the debenture loan of 1881. This had been entirely paid off on the 1st January last, and the expenses towards the amortization of, and interest on, debentures had been reduced from £49,250 in 1889 to £37,500 in 1890, and would henceforth only amount to about £20,000. It was to be hoped that the saving thus effected in the yearly expenses of the Company would amply counterbalance the before-mentioned tariff reductions during the period which would elapse before the natural development of the traffic could gradually effect the same object. It might also be considered an advantage that the new tariffs would not come into force until the 1st July next, the loss incurred during the first twelve months being thus spread over two financial years.

Distribution of Profits.—Owing to this favorable position, the Board of Directors had been enabled to recommend that the extra dividend, which, after the Berlin Conference had been reduced to 5s., be increased by 2s. 2d., making the total dividend for the year 17s. 2d. per £10 shares, or about 8·60 per cent. They also recommended to add a somewhat larger amount than usual to the reserve fund, in order to meet the heavy expenses in connection with the laying of the new cables.

Obituary.—From the foregoing remarks it would appear that the year 1890 had been a very active one, and it might at the same time have been called a very fortunate one in every respect had the Board of Directors not sustained a sad and irreparable loss through the demise of two of their collaborators. Mr. L. P. Holmblad, who had been on the Board ever since the formation of the Company, died at Copenhagen on the 16th November last, deeply lamented by his fellow-directors and by all who knew him. Mr. H. G. Erichsen, who had taken a most active part in the promotion of the Company, and whose enlightened mind and great business capacity had been of invaluable service to the Company, died on the 6th December last, in London, where he had acted as the Company's representative for a great number of years. He had been succeeded by Mr. F. C. C. Nielsen, the Company's manager in London.

The report and balance-sheet, together with the propositions as to the distribution of the balance, were unanimously adopted.

The retiring Director, A. Garde, Esq., was re-elected Director; and A. Berner, Esq., and S. Bille, Esq., were re-elected as Auditors.

Seven shillings and twopence per £10 share, representing the final dividend for 1890 upon the Great Northern Company's Stock, are now payable at the Company's bankers, Messrs. C. I. Hambro & Son, No. 70, Old Broad-street, London, E.C., against Coupon No. 21.

Oriental Telephone Company (Limited).

An extraordinary general meeting of this Company was held at the offices of the Company, 14, Austin Friars, E.C., on Wednesday, the 6th inst., Mr. Wm. Addison in the chair, when the following resolution, which was passed at the meeting held on April 15th, was confirmed as a special resolution, viz.:—

"*That the following resolution passed at the ordinary general meeting of the Company held on April 15th*, 1891, *be confirmed as a special resolution*":—

"*That the Company's Memorandum of Association be altered as follows*:—

"*By adding at the end of paragraph (b) of Clause 3 the words 'or generation, employment, or utilisation of electricity or magnetism.'*

"*By inserting after the said paragraph (b) the following additional paragraph*:—*(bl), 'To carry on any business or manufacture relating to the generation, employment, or utilisation of electricity or magnetism, or the apparatus connected therewith.'*"

This was moved by the CHAIRMAN, and seconded by Mr. HENRY GRÈWING, and carried.

Kensington and Knightsbridge Electric Lighting Company (Limited).

The annual general meeting of this Company was held on Monday, the 4th inst., at 1, Great George-street; Mr. Granville R. Ryder in the chair.

The SECRETARY (Mr. R. S. Erskine) having read the notice convening the meeting, and the minutes of the last meeting,

The CHAIRMAN, in moving the adoption of the report and accounts, said that during the year ending 31st December last about four miles of mains had been laid, leaving only about three-quarters of a mile to be laid to complete the whole of the Company's compulsory area. During the year the number of houses and shops connected with the Company's system had increased from 147 at the end of 1889 to 291 on December 31st, 1890; while the number of lamps calculated on the usual basis of 8 c.p. had increased during the same period from 11,794 to 25,535. The shareholders would probably like to know that at the end of April the number of customers had increased still further to 342, and the number of lamps to 30,455, which was very satisfactory. With regard to the accounts, which, on the suggestion of the auditors, had been prepared in a more simplified manner, he did not know that there was any special item requiring explanation. What would perhaps most interest the shareholders was, what were the prospects of the Company It was true that customers had not come forward to the extent they would have liked, but he was hopeful of the future, and thought it was only a question of time when the business of the Company would largely be increased. The secretary had been for some time making careful calculations as to the average gross income from each lamp per annum, and he found it worked out at 10s., which, if they had 40,000 lamps, would produce £20,000. This they reckoned would give a net profit of from 35 to 40 per cent., which, after paying the Preference shareholders, would leave sufficient to pay a good dividend on the ordinary shares. With reference to the powers the Directors proposed to take for raising additional capital, they had carefully gone into the question before deciding to ask for these further powers, and the shareholders might be perfectly certain that the money would not be spent unless the Directors could see their way to doing so in a satisfactory manner. The secretary had calculated that an expenditure of £10,000 on plant, mains, &c., would add 10,000 lamps, which meant a net profit of £2,000. The Directors asked for a free hand in the matter of the new issue. Under the Articles of Association they had powers to issue debentures or debenture stock without the sanction of the shareholders, but they proposed to do the same thing in another way. They only proposed to issue £10,000 of new shares at first. It was satisfactory for the shareholders to know that the profits of the Company for the first three months of the year were sufficient to pay 6 per cent. to the Preference shareholders for the half-year, and to carry forward a small balance.

The motion for the adoption of the report and accounts was seconded by Mr. G. H. HOPKINSON, and, after some remarks by Mr. KILLINGWORTH HEDGES and Mr. PARKER YOUNG, it was carried.

The CHAIRMAN then proposed:—

"1. *That the capital of the Company be increased by the creation of* 10,000 *new shares of* £5 *each, to be called Second Preference Shares.*"

"2. *That the Second Preference Shares shall be issued at such times, for such amounts, under such conditions, and at such rate of interest, as shall be determined by the Directors.*"

"3. *That the holders of the Second Preference Shares shall have no right of voting at any general meeting in respect of such shares.*"

Mr. HOPKINSON seconded.

Mr. R. E. CROMPTON, in the course of a few remarks, spoke hopefully of the prospects of the Company. There had been a hanging back on the part of consumers at the beginning of the year, but they were now going on at a better rate. If the ordinary shareholders had patience, they would yet see their investment paying a good interest, and he was sure they would ultimately find their shares a valuable property.

After a few remarks from a SHAREHOLDER, who complained that the estimated expenditure had been much exceeded, which, however, was explained by the CHAIRMAN, the motion was carried.

On the proposition of Mr. HOPKINSON, seconded by Mr. PARKER YOUNG, Mr. Granville R. Ryder was re-elected a Director, a like compliment being paid to Mr. R. W. Wallace, on the motion of Mr. Granville R. Ryder, seconded by Mr. Killingworth Hedges; and the auditors, Messrs. Lovelock, H. W. Whiffen, and Dickenson, having been re-appointed, the meeting terminated with the usual vote of thanks to the chair.

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Submarine Cables Trust.

The twentieth ordinary annual meeting of the certificate holders in the Submarine Cables Trust was held at the offices, Winchester House, Old Broad-street, on Tuesday, under the presidency of Sir John Pender, K.C.M.G.

The SECRETARY (Mr. Lewis Wells) read the notice convening the meeting, and the minutes of the last general meeting; and the report of the Directors was taken as read.

The CHAIRMAN then said: Our revenue for the past year amounted to £23,666, as against £23,094 in 1890, showing an increase of £572 Of this increase £264 arises from a small profit made by the trustees on a temporary investment of their funds, and the remainder from an improvement in the dividend received on their investment in Anglo-American Stock. Our expenses for the year amounted to £1,175, as compared with £1,274 in 1890, showing a saving of £99. Our expenses for the years 1888 and 1889 were over £1,380. We are, therefore, working at the rate of £205 per annum less than formerly, the economy shown being mainly due to our not having filled up the vacancy on the Board caused by the death of Sir Daniel Gooch. The small increase in revenue, coupled with a decrease in expenses, may be regarded as satisfactory. The accounts before you show that we are now earning 6¾ per cent. on the amount of our outstanding certificates. Our coupons, as you all know, are six months in arrear. While we are in this position the certificate holders will receive, in addition to the usual 6 per cent., as much as possible in reduction of the overdue coupon. We propose paying £1 on the 15th inst., and the balance of £2 as soon as we have sufficient money in hand for the purpose. As you are aware, this Trust is dependent for its success on the dividends it receives from the Submarine Telegraph Companies whose stocks it holds. During the time when we fell behind with our coupons there was great competition in connection with the Atlantic cables, and this very much reduced the dividend we received from the Anglo-American Company. Submarine cables are now doing better, and as they improve, and their revenues and dividends increase, so this Trust will benefit to a corresponding extent. We do nothing of ourselves. We have simply to watch carefully the proceedings of other companies, and I think I may say that at the present moment the companies in which we hold a large interest are, all round, in a very satisfactory position. With these remarks I beg to propose:—

"That the report and accounts of the trustees, now submitted to the meeting, be approved and adopted."

The Most Hon. the Marquis of TWEEDDALE: I beg to second the motion.

The CHAIRMAN: If any gentleman desires to put any question to me I shall be glad to answer it.

No one rising to address the meeting, he put the resolution in the usual way, and declared it carried unanimously.

On the motion of Mr. BLACKLEY, seconded by Mr. K. Anderson, the retiring auditors, Mr. John G. Griffiths and Mr. John Gane, were re-elected for the current year.

The CHAIRMAN: That is all the business. I might add just a word in regard to this Trust. You are aware that it is very much on the principle of a tontine. I do not see how I can hope that many of those who are now before me can come in at the winding up. When we can pay our coupons up to date our surplus revenue will be employed as formerly, in buying up certificates, and eventually this affair must fall into the hands of a very few persons.

A cordial vote of thanks was then passed to the Chairman and Directors.

The CHAIRMAN: I am very much obliged to you for the compliment. As you know, we happen to be very much interested in all the other companies. We know, therefore, how they are going on; and, indirectly, we are able to watch after the interest of this Trust from day to day. I think I may venture to assure you that we are now in an improving position, and I look upon this concern as a very good investment indeed.

Western and Brazilian Telegraph Company (Limited).

The following is the report of the Directors to be presented at the twenty-first ordinary general meeting of the Company, to be held at Winchester House, Old Broad-street, London, E.C., to-day (Friday), May 8th, at 12 noon:—

The total earnings amount to £108,817. 10s. 5d., as against £86,403. 0s. 7d., showing an increase of £22,414, 9s. 10d., compared with the half-year to December 31, 1889. The working expenses amount to £37,200. 2s. 4d., as against £40,391. 11s. 9d., a decrease of £3,191. 9s. 5d. Including the amount brought forward from June 30, 1890 (£5,751. 7s.), and the dividend received upon the shares held in the "Platino" Company, the balance to the credit of the revenue account is £86,602. 5s. 1d., from which has been deducted £13,164 for debenture interest, and £5,936 for the debenture redemption fund, leaving £67,502. 5s. 1d., of which £20,000 has been placed in the reserve fund. The Directors now recommend the payment of a dividend of 9s. per share, free of income tax, on the ordinary shares for the half-year, making with the dividend paid in November last, £5 per cent. for the year, leaving a balance of £6,070. 6s. 1d. to be carried forward. In the case of shares which have been divided into "preferred" and "deferred," 1s. 6d. per share of the dividend now recommended will be payable to the "preferred" shareholders, and 7s. 6d. per share to the "deferred" shareholders.

The second annual drawing of the A and B debentures took place at the Company's offices on January 16th last, in the presence of Mr. W. W. Venn, jun., Notary, when debentures amounting to £11,900 were drawn, and have since been paid off at par.

A contract for the duplication of the Company's lines between Pernambuco and Santos has been entered into with the India Rubber, Gutta Percha and Telegraph Works Company (Limited). The ship carrying this cable will leave in a few days.

Since the last report ten "Platino" shares have been exchanged for six shares of this Company.

The dividend warrants will be posted on May 15, 1891.

The retiring Directors are Mr. W. S. Andrews and Lord Richard H. Browne, who offer themselves for re-election. The Auditors, Mr. John Weise and Mr. John G. Griffiths, retire, and are eligible for re-election.

West India and Panama Telegraph Company (Limited).

The following is the report of the Directors for the half-year ended 31st December, 1890, to be submitted to the twenty-eighth ordinary general meeting, to be held at Winchester House, Old Broad-street, E.C., on Wednesday, the 13th inst., at 12 o'clock:—

1. The amount to credit of revenue is £43,978. 19s. 8d. (against £42,768. 0s. 1d. for the corresponding half-year of 1889), and the expenses have been £21,898. 3s. 11d. (against £27,071. 7s. 0d. for the same period in 1889), leaving a balance of £22,080. 15s. 9d., which, with £322. 6s. 8d. brought from last account, make a total of £22,403. 2s. 5d., with which it is proposed to deal as follows:—

	£	s.	d.
First Preference Shares—			
Dividend, 6 months to 31st Dec., 6s. per share ...	10,368	18	0
Second Preference Shares—			
Balance of arrears of dividend to 30th June, 1890, 28s. 6d. per share.....	6,653	6	6
Dividend, 6 months to 31st Dec., 6s. per share...	1,400	14	0
Ordinary Shares—			
9d. per share (free of Income Tax)	3,312	0	9
Balance to current half-year's account	668	3	2
	£22,403	2	5

2. The traffic receipts for the six months show an increase of £1,608. 10s. 2d. as compared with the corresponding period.

3. The expenses of repairs to cables amount to £9,155, being £4,966 less than those for the corresponding six months.

4. Referring to the Directors' Report of the 23rd April, 1890, the result of the negotiations with the Colony of Martinique has been the acceptance by the Company of £500 in settlement of its claims.

5. The shareholders have already been informed that negotiations were pending for laying a new cable between Demerara and Trinidad. These negotiations have resulted in an Ordinance of the present year enacted by the Governor of British Guiana and the Court of Policy, by which an annual subsidy of £4,500 is payable to the Company during a period of 10 years, subject to the laying of a new cable between that colony and Trinidad, and the maintenance of telegraphic communication in terms of the said Ordinance. The Directors recommend that this cable should be laid in the course of this year, for which purpose, as also for the Barbados-St. Vincent cable laid in July last, a sum not exceeding £50,000 will be required, and as the existing £50,000 Five per Cent. Debentures fall due on the 31st December next the shareholders will be asked to empower the Board to borrow a sum of £100 000 and to issue Debentures or other securities at such times, with such security, and upon such terms as the Directors may think proper. The borrowing powers of the Board will thus be limited to the £100,000, which will be applied for the new cables and the payment at maturity of the £50,000 existing Debentures. Considering the loss sustained by the Company in the past from the suspension of subsidies, loss of traffic, the heavy expenses of forwarding messages during interruptions in the above sections, and the serious cost involved in urgent repairs, the Directors are of opinion that the telegraphing public, as well as all classes of the Company's shareholders, will be benefited by the proposed outlay.

6. It will be remembered that the original subsidy of £800 per annum granted by the colony of St. Vincent was in consequence of the severe commercial depression reduced in 1887 to £400 per annum. An improvement in the colony's finances having taken place the subsidy has now been increased to £600 per annum—a considerate recognition of the Company's need for support which the Directors have much satisfaction in acknowledging.

7. The s.s. "Duchesse of Marlborough" has been brought home for repairs. She arrived on the 4th instant, and on the completion of her repairs she will take out 70 knots of cable which is now being manufactured by Siemens Brothers and Co., Limited.

8. In accordance with the Articles of Association, Charles William Earle, Esq., and William Ford, Esq., retire at this meeting, and offer themselves for re-election. John George Griffiths, Esq., the Auditor, also retires, and offers himself for re-election.

Western Counties' and South Wales Telephone Company (Limited).

The following is the report of the Directors to be presented to the shareholders at the sixth annual ordinary general meeting of the Company, to be held at the Grand Hotel, Broad-street, Bristol, on Friday, the 15th day of May, 1891, at 2 p.m.:—

Capital Expenditure.—The capital expenditure for the year ending December 31, 1890, was £24,415. 15s. 6d., making a total of £164,409. 12s. 2d. to date.

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Revenue.—The gross revenue of the Company for the year 1890 was £46,860. 15s., against £39,046. 19s. 6d. for the year ending December 31, 1889. The amount of income carried forward to next year's revenue, as representing sums received in advance for periods extending beyond December 31, 1890, is £14,212. 19s. 1d., against £12,292. 19s. brought in from the previous year.

Maintenance.—The whole of the Company's plant has been fully maintained and, where required, renewed out of the revenue. The Company have continued to substitute, at considerable expense, a large amount of copper and bronze wire for iron, which has increased the efficiency and durability of the plant.

Working Expenses.—The working expenses, including maintenance and all working charges for the year 1890, have been £13,775. 18s. 1d., against £11,936. 18s. 5d. for the year ended December 31, 1889.

Dividend.—Balance of net revenue account, £9,177. 7s. 3d.; dividend of 6 per cent. on the paid-up Preference share capital for the year ended December 31, 1890, £6,000; balance for appropriation, as per statement at end of accounts, £3,177. 7s. 3d.

The Directors recommend that the reserve fund, now standing at £1,700, be increased by the addition of £500; and that the balance, £2,677. 7s. 3d., be carried forward.

Growth of Business.—The number of subscribers to the exchange system and of private line renters has considerably increased, and the progress made during the year is considered to be most encouraging. The respective totals at the close of the years 1889 and 1890 were as follows:—

	Exchange.	Private.	Total.
December 31, 1890	2,875	712	3,587
December 31, 1889	2,392	671	3,063
Increase in 1890	483	41	524

Mileage of Trunk and Renters' Wires.—Erected up to December 31, 1890, 5,018 miles; erected up to December 31, 1889, 4,115 miles; increase representing new business during 1890, 903 miles. In addition to the above, 160 miles of wire have been renewed during the year.

Trunk Lines.—The Company has increased its trunk system, so that on December 31, 1890, it had 470 miles of trunk pole lines connecting towns with each other, carrying 2,182 miles of wire, against 383 miles of pole lines, carrying 1,804 miles of wire, at the corresponding date in the previous year. The continued rapid growth of the use of the Company's extensive system of trunk lines will be seen from the following figures:—

	Calls.
4 months ending December, 1887	27,338
12 " " 1888	142,443
12 " " 1889	184,754
12 " " 1890	249,160

Each call is answered, so that the number of communications has been double these figures. The foregoing figures form conclusive evidence of the increasing appreciation by subscribers and the public of the convenience and economy of telephonic intercommunication between towns, and represent a remarkable development of this branch of the Company's business.

London.—The Company has continued to keep in view the importance of connecting the principal towns of their district with the Metropolis, and arrangements with the National Telephone Company for the construction of a line putting Bristol and the south-western district and South Wales in direct communication with London have been frequently considered. It is also intended to connect Bournemouth, Southampton, and Portsmouth with London, *viâ* Winchester, Basingstoke, and Reading, when the necessary arrangements are completed.

Birmingham, Manchester, Liverpool.—Many inquiries having been received urging the importance of a connection with these great centres, trunk lines have been run between Gloucester, Worcester, and the boundary of the National and this Company's districts; thus that portion of this Company's extensive trunk line system, embracing Bristol, Bath, Gloucester, Newport, Cardiff, Swansea, &c., is now in communication with Birmingham, Liverpool, and Manchester, and the many other important towns connected therewith in the North and Midland district.

Public Call Rooms and Trunk Toll Messages.—Additional call rooms for the use of subscribers and the public have been opened during the year in the various towns, where, on payment of 2d., the Company's local exchange subscribers may be spoken with; or, on payment of a small toll, according to distance, any person can speak to any town connected by trunk lines; the Company's subscribers and their representatives having the important advantage of the free use of all call rooms in any town in the Company's district where they may happen to be, for local communication with other subscribers in that town.

Ladies' Free Call Room Passes.—A further and novel extension of call room facilities has just been made by the Company issuing a complimentary call room pass for use by the lady members of subscribers' families available for local calls made by the bearer in any town in the Company's district where there is a call room. The convenience of the telephone to ladies when in the neighbourhood of any of the Company's numerous call rooms will not fail to be appreciated, while at the same time the Company will gain advantage by making their extensive system of telephone exchanges better known and increasingly popular.

The Post Office.—The Directors have pleasure in acknowledging the uniform courtesy of the permanent officials of the Post Office department.

Retiring Directors and Auditors.—Mr. Charles Nash and Mr. Richard Cory retire by rotation, but are eligible for re-election. Messrs. Hudson Smith, Briggs and Co. retire, but are eligible for re-election.

NEW COMPANIES REGISTERED.

ARMSTRONG'S GLASS COMPANY (LIMITED).—Registered with a capital of £10,000 in £10 shares. Object: To carry into effect an agreement expressed to be made between John Armstrong of the one part and the company of the other part, for the purchase of certain patent rights and inventions, and to carry on, at Albion, Staffordshire, and elsewhere, the business of glass manufacturing in all its branches.

BRITISH ELECTROLYTIC SYNDICATE (LIMITED).—Registered by Alfred Wells, 27, Chancery-lane, W.C., with a capital of £100,000 in £1 shares. To carry into effect an agreement expressed to be made between Frederick Bennett of the one part and the Company of the other part, and to carry on generally the business of miners, metallurgists, and smelters. The first subscribers are:—F. Safford, 2, Garden-court, Temple, E.C.; T. Lewis, Bryn Ogwen, Bangor; W. J. Tippetts, 11, Maiden-lane, Queen-street, E.C.; A. McLaren, 42, Newsome-street, Cootham, Redcar; H. T. Middleton, 8, Princes-street, Westminster, S.W.; A. C. Hutchins, Drayton Lodge, Ealing Dean, W.; A. J. Jordan, Keymer Vale, Keymer, Sussex. There shall not be less than three nor more than seven Directors; the first shall be appointed by the subscribers to the Memorandum of Association. Qualification, £100. Remuneration, £1,000, with a further 5 per cent after 15 per cent. dividend.

ELECTRICAL ADVERTISING SYNDICATE (LIMITED).—Registered with a capital of £10,000 in £10 shares. Object: To acquire certain patents relating to the application of electrical energy to the purposes of advertisements and to develop the same.

T. L. HEMMING AND CO. (LIMITED).—Registered with a capital of £5,000 in £10 shares. Object: The acquisition of the business of an electrical and general engineer, now carried on by Thomas Lynch Hemming, John Thornton and Thomas Richard Canning, trading as T. L. Hemming and Co., at 96 New John-street West, Birmingham, and to develop and extend the same.

NEW COMPANIES IN APRIL.—The total number of new companies registered at Somerset House in April was 230, with a total capital of £17,676,558, of which amount, according to the *Financial Times*, electricity in its various uses was responsible for £302,000, and engineering and general metal working for £433,000.

ARTHUR D. STUDD AND CO. (LIMITED).—Registered with a capital of £8,000 in £5 shares. Object: To acquire the business of an engineer and ironfounder now carried on by A. D. Studd, at Kettering.

WHESSOE FOUNDRY COMPANY (LIMITED).—Registered by Andrew Mellor and Smith, 27, Clement's-lane, E.C., with a capital of £50,000 in £10 shares. Object: To acquire the undertaking heretofore carried on under the style of the owners of the Whessoe Foundry, at Darlington, Yorkshire, and to carry on generally the business of mechanical, electrical, and consulting engineers, &c.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the past week amounted to £5,444.

CITY AND SOUTH LONDON RAILWAY COMPANY.—The traffic receipts of this Company for the week ended May 3rd amounted to £733.

CONSOLIDATED TELEPHONE CONSTRUCTION AND MAINTENANCE COMPANY.—The Directors of this Company recommend dividends at the rate of 6 per cent. on the preference shares and 7 per cent. on the ordinary shares, less income-tax, making 6 per cent. per annum on both descriptions of shares for the year ending March 31st.

CUBA SUBMARINE TELEGRAPH COMPANY.—The estimated traffic receipts of this Company for the month of April were £3,700, as compared with £3,624 in the corresponding month of last year.

DIRECT SPANISH TELEGRAPH COMPANY.—The traffic receipts of this Company for the month of April, 1891, amounted to £1,825, as against £2,089 in the corresponding period of last year, or a decrease of £264.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this Company for April were £60,909, as against £55,042 for the same period of 1890 an increase of £5,867.

EASTERN EXTENSION TELEGRAPH COMPANY.—The receipts of this Company for April amounted to £44,729, as against £40,696 in the corresponding period, showing an increase of £4,033.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of this Company are as follows:—Receipts in April, 1891, £23,600; 1st January to 31st April, 1891, £88,000; corresponding months, 18.0, £81,800; corresponding months, 1889, £84,000.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The receipts o this Company for the two weeks ended April 30th show a decrease of £712 as compared with the corresponding period.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended May 1, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,363.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, April 29.		Price Wednesday, May 6.		Rate per Cent. Yielded	Dividend Due.	Business Done During Week Ending May 6.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS.								
£1,381,380	Stock	12/0	Anglo-American ..... xd	46½	47½	47	48	5 19 9	Jan., Apr., July, Oct.	49½	48½
£2,809,310	Stock	21/0	Do. Preferred ..... xd	84	85	85	86	6 13 9	" "	88	84
£2,809,310	Stock	..	Do. Deferred	11½	12	12	12½	..	" ..	13⅞	11⅞
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99	102	99	102	3 18 5	January and July ..	100¾	99
130,000	£10	3/0	Brazilian Submarine	11½	12	11½	12	6 5 0	Mar., June, Oct., Dec.	12	11⅝
£84,500	£100	5%	Do. 5 per Cent. Bonds	101	104	101	104	4 16 2	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)....	104	108	104	108	4 12 7	June and December	..	..
$7,216,000	$100	7%	Commercial Cable Capital Stock	108	110	108	110	6 7 3	April and October ..	..	..
16,000	10	8/0	Cuba Submarine	10½	11½	10½	11½	6 19 2	February and August	10¾	10½
6,000	10	10%	Do. Preference 10%	16½	17½	16½	17½	5 14 3	" "	..	..
12,931	5	3⅛	Direct Spanish (£4 paid)	3¾	4¼	3¾	4¼	6 11 9	April and October ..	4	..
6,000	5	12%	Do. Preference 10%	9	10	9	10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States ..... xd	10	10½	10⅜	10⅝	6 15 0	Jan., Apr., July, Oct.	10½	..
400,000	10	2/6	Eastern	14½	14⅝	14⅜	14⅝	4 8 10	" "	14⅝	14⅜
70,000	10	6%	Do. 6 per Cent. Preference	15½	15⅝	15½	15⅝	3 16 2	" "	15 7/16	15⅜
£1,200,000	Stock	6%	Do. 4 per Cent. Mort. Debenture Stock.. xd	106	109	106	109	3 13 5	May and November	107½	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 10 11	February & August	..	..
250,000	10	6/6	Eastern Extension ..... xd and Bonus	14¾	15¼	14¾	15¼	4 13 4	Jan., Apr., July, Oct.	15¼	14¾
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock	105	108	105	108	3 14 1	..	106⅜	..
£91,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103	106	103	106	4 14 4	January and July ..	..	..
£145,300	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900..	103	106	103	106	4 14 4	" "	..	..
180,227	10	2 6	Globe Telegraph and Trust	9⅛	9⅜	9¼	9½	5 7 10	Jan., Apr., July, Oct.	9⅜	9¼
180,042	10	6%	Do. 6 per Cent. Preference	14⅜	15⅛	14¾	15⅛	3 19 4	" "	15⅛	14⅞
150,000	10	7/2	Great Northern ..... xd	17¾	18¼	18	18½	..	Jan., April, and July	17 1/16	17⅞
£15,000	100	5%	Do. 5 per Cent. Debentures, 1881	..		..		..	January and July ..	..	..
£230,000	100	5%	Do. 5 per Cent. Debentures, 1883	105	108	105	108	4 12 7	March & September	..	..
17,000	25	12/6	Indo-European	42	44	42	44	5 13 8	May and November	..	..
38,348	10	4 0	London Platino-Brazilian	7	8	7	8	5 0 0	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106	109	106	109	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's	8¾	9¼	8½	9½	5 8 8	April and October..	..	..
3,381	£100 Cert.	6%	Submarine Cables Trust 6%	115	120	116	121	4 19 2	" "	117⅜	117
15,609	10	4/0	West African Telegraph	8	9	8	9	5 11 1	January and July ..	..	..
£200,900	100	5%	Do. 5 per Cent. Debentures	98	101	98	101	4 19 0	March & September	99	98
30,000	10	3/0	West Coast of America	3	4	3	4	..	January and July ..	..	..
£150,000	100	8%	Do. Debentures 8% 1902	94	99	97	10½	..	June and December	..	..
88,321	10	9d.	West India and Panama	3⅜	3⅝	3½	3¾	..	..	3 5/16	3 5/16
34,563	10	6/0	Do. 1st Preference 6%	11¾	12¼	11¾	12¼	4 18 0	May and November	12⅛	12
4,669	10	£3	Do. 6 p. c. 2nd Pref.....	11½	12½	11½	12½	4 16 0	" "	..	..
64,174	15	6/0	Western and Brazilian	12½	13	12½	13	4 13 0	" "	12⅝	12⅜
27,873	7½	6/0	Do. 5 per Cent. Cumulative Preferred	6¾	7½	6¾	7½	5 4 2	—	..	..
27,873	7½	4/6	Do. 5 per Cent. Deferred	5½	6	5½	6	..	..	5¼	5¼
£200,000	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103	106	103	106	5 13 2	February & August	..	..
£250,000	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103	106	103	106	5 13 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage ..... xd	120	125	117	122	5 14 9	May and November	..	..
£175,100	£100	6%	Do, 6 per Cent. Sterling Bonds	100	104	100	104	5 15 5	March & September	..	..
			TELEPHONES.								
224,850	14/0	0/4½	Consolidated Telephone Const. & Maintenance. ..	1 7/16	1 9/16	1 7/16	1 9/16	7 9 4	May and November	..	..
220,000	£1	4·76	Oriental (11s. paid) ..... xd	¼	⅜	¼	⅜	5 2 11	Yearly	..	..
438,984	5	2/6	National	4½	4⅝	4½	4⅝	6 2 3	June and December	4⅝	4 5/16
15,000	10	6/0	Do. 6 per Cent. Cumulative 1st Pref.	13	13½	13	13⅝	4 8 11	" "	13 1/16	..
15,000	10	4/9⅜	Do. 6 per Cent. Cumulative 2nd Pref (£8 pd)..	10	10½	12	12⅝	..	" "	..	..
..	£100	..	Do. Debentures 4½% Prov. Cert. (fully paid)..	102	104	102	104	..	..	103½	103
209,750	1	..	South of England, Ordinary	⅛	¼	..		..	—	..	..
20,000	5	..	Do. 6 per Cent. Cumulative Pf. (£3 10s. pd)..	3	3½	..		..	..	..	..
58,000	5	1/0	United River Plate	2½	3½	2½	3½	..	January and July ..	..	..
£146,128	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 3	..	..	..
£3,200	100	..	Do. 7 per Cent. Debentures	..		..		..	—	..	..
			ELECTRICITY SUPPLY COMPANIES.								
1,000	£50	..	City of London Electric Lighting Shares (£25 pd)..	32	34	32	34	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	4⅛	5	4⅛	5	..	..	..	..
5,322	£5	3½%	House to House Electric	4½	5⅛	4½	5⅛	..	..	..	..
30,000	£5	..	Liverpool Electric Supply (£3 paid)	2⅝	2¾	2⅝	2¾	3 13 1	..	..	..
111,000	5	..	London Electric Supply	2⅛	2⅜	2⅛	2⅜	..	..	..	..
43,900	10/0	2/0	Metropolitan Electric Supply (£9 paid) ..... xd	9	9½	9	9½	4 5 4	..	9 1/16	9¼
7,730	£5	..	St. James' and Pall Mall	5⅞	6⅛	5⅞	6⅛	..	..	..	..
..	..	..	Do. 7% Preference	⅜	½ pr em.	⅜	½	..	..	..	..
42,853	5	..	Westminster Electric Supply (£5 paid)	4⅛	5⅛	4⅛	5⅛	..	..	5	4 13/16
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
63,416	3	..	Brush Electrical Engineering	2⅜	2⅝	2⅜	2⅝	..	..	2 7/16	2⅜
63,416	2	1/1	Do. 6 per Cent. Preference	1⅝	1⅞	1⅝	1⅞	6 8 0	June and December	1⅝	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	4	5	4	5	7 0 0	January and July ..	..	..
17,139	5	..	Edison and Swan United	..		..		..	—	..	..
45,000	10	6%	Electric Construction	5	6	5	6	..	—	..	..
70,000	2	10/0	Elmore's Patent Copper Depositing	2¾	3¼	2¼	2⅞	..	—	2¾	2¼
20,000	5	..	Fowler-Waring Cables (£4 paid).....	2½	3½	2½	3½	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works...	18½	19½	18½	19½	5 2 7	February & August	19¼	19
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	104	102	104	4 6 7	March & September	..	..
11,334	£10	6/1	International Okonite Limited Ordinary	7½	8½	7½	8½	11 15 3	..	..	..
11,334	£10	5/0	Do. Preference	9½	9¾	9¾	9¾	8 4 1	..	..	..
78,949	5	4/10½	Swan United (£3. 10s. paid)	4¾	5¼	4¾	5¼	6 13 4	May and November	4⅞	4¾
37,350	12	36/0	Telegraph Construction and Maintenance.....	45	47	45	47	5 0 0	March and July.....	47	46½
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	102	105	102	105	4 15 3	January and July ..	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£2. 10s. paid)..	2⅜	2¾	2⅜	2¾	..	..	..	..
—	£5	..	Do. Preference (fully paid).....	3⅜	4⅛	3⅜	4⅛	..	..	..	..
			RAILWAYS.								
50,000	£10	..	City and South London Railway	5½	6½	5½	6½	..	..	..	..

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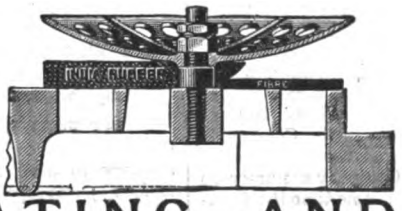

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

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NOTES.

The meeting of the Physical Society, at Cambridge, on Saturday last, was a brilliant innovation on the ordinary, sometimes very ordinary, meetings at South Kensington. About 100 members and visitors left by the 11 a.m. express, and on arriving at Cambridge became the guests of the Cambridge members, and proceeded to Emmanuel College. After a stroll in the Fellows' garden, they were entertained at lunch in the college hall, under the presidency of Mr. W. N. Shaw. A meeting of the Society was held in the lecture room of the Cavendish Laboratory. Prof. J. J. Thomson had the temerity to offer some very interesting experiments, which depended on the action of an influence machine. The rehearsal, a few minutes before the meeting, had gone off excellently, as rehearsals do, but on attempting to repeat them before the audience the machine stubbornly refused, as influence machines do, to yield a spark, notwithstanding the presence of Mr. Wimshurst and Dr. Oliver Lodge. The application of warm blankets and other restoratives subsequently brought it round, and the experiments, which duly "went off," will be reported in our columns next week.

After the meeting, the visitors inspected the Cavendish and other laboratories. "The Cavendish" was not in its usual working condition, for a number of the historical relics and portions of apparatus used by Maxwell were displayed for the occasion; many of these were easily recognised by the visitors from the illustrations of them in his works. The requirements and the function of the Cavendish Laboratory differ very widely from those of the Technical Colleges, and we understand that some of the members who are connected with these institutions were struck with the large amount of valuable apparatus in the cupboards besides that in use and out on show for the occasion. They noticed that, except for elementary work, little or no apparatus was permanently fitted up for rapid measurement with a fair degree of accuracy, the fact being that the line between elementary work and research is very sharply drawn. The excellent text-book on Practical Physics by Glazebrook and Shaw gives a fair notion of the students' course, and the principle of encouraging them to acquire a working knowledge through a considerable range and variety of branches, rather than to spend all their time in carrying out a few elaborate measurements.

In the private rooms were shown, among other things, the 50-foot vacuum tube used by Prof. J. J. Thomson in his recent research, alluded to on page 658 of our last volume; while Mr. Shaw exhibited his ingenious adaptation of the principle of the Wheatstone bridge to the measurement of the friction of air in passing through various orifices and tubes, thus resuscitating the well-nigh extinct science of Pneumatics. The "Warden of the Ohm" showed his spectrophotometer, some new Clark cells, and various resistance standards, both ancient and modern; and, in the room which was once occupied by Maxwell, the Cambridge Scientific Instrument Company, represented by Mr. Horace Darwin, exhibited numerous specimens of their work, including a dividing engine, Boy's radio-micrometer, and several different kinds of recording instruments, one of which, intended for registering the growth of plants, was engaged in recording the loss of weight of a burning candle.

Mr. Vignoles' Paper, which we print in this issue, contains an account of the magnetic researches carried out by the writer, in conjunction with Mr. Evershed. It forms an excellent summary of the principal facts known about commercial specimens of iron, and, while necessarily describing much that is well known, presents several novel features. The experiments differ from those of Prof. Ewing in that they were carried out in the shops, and not in the laboratory; closed rings of iron were used instead of long bars, and the masses of iron dealt with were considerably greater. The method of test also seems a distinct improvement on that of Prof. Ewing, and, as Prof. Ayrton suggested, it could have been still further improved if the two magnetising coils, instead of being separate, had been wound over the same part of the ring. The results, moreover, could have been more confidently applied to transformers if an additional coil, doubly wound like an ordinary resistance coil, had been wound round the ring and subjected to the passage of a strong current. The opposing magnetising effects of the two parts of this coil would have produced magnetic leakage, such as is caused in a transformer, owing to the action of the primary and secondary currents, and probably the permeability and hysteresis curves would be similarly affected in the two cases. The Paper was followed by an unusually vigorous and critical discussion, which we hope to publish next week.

The train-lighting dynamo which we describe this week appears at first sight to be needlessly complicated. That the

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details should be more intricate than is usual in modern dynamos is to be expected, since the conditions under which it is used are peculiar; but it is found to work well, and additional trains are being fitted according to the system described by Mr. LANGDON at the Institution of Civil Engineers last week. On several lines it has been found impossible to give proper care and attention to steam dynamos mounted on the engine, and in attempting to drive from the axle many difficulties present themselves. Accumulators must be used, and while these may be a blessing to a central station engineer, they are generally found to be a nuisance by most other persons, and under the difficult conditions of railway work have severely taxed the patience of those who have had to deal with them.

SUCH trains as those which run on the Brighton line are, of course, quite easy to light by electricity, but where stoppages are frequent, and, above all, where the train is separated into different portions, the problem is no simple one. It was the latter difficulty which proved too much for the axle-driven system, tried on the Lancashire and Yorkshire Railway in 1885. The reversing switch and some other details were the same as those on the HOLMES dynamo, but it was found necessary to begin to charge at about 18 miles an hour, or there would not have been time during the day to charge the batteries. It is here where express trains have an advantage over slow or stopping trains which cannot be lit by axle driving. While alluding to this experiment in 1885 we take the opportunity of remarking that wire gauze brushes cut "on the bias" were used. They were rolled up, to the size and shape of cigarettes, and each one was pushed up to its work by a spiral spring. They were set square against the commutator, which ran in either direction. They are not claimed in the patent, and are therefore not patentable.

THE insecurity of lead-covered wire under certain conditions is strikingly exemplified by some seriously corroded specimens which have been sent to us by Sir DAVID SALOMONS. He informs us that the wire is of Swiss manufacture, and that it was laid on wood in a thoroughly dry place about four years ago. In reply to our inquiries we learn that it was run between the ceiling and floor, resting on the laths at places, and here and there on yellow deal. The wire is about No. 22 S.W.G., and is covered to about 115 mils with a fibre resembling jute impregnated with Stockholm tar. Over this is a thin and apparently irregular covering of lead varying from 15 to 20 mils in thickness, bringing the exterior diameter up to about No. 8 B.W.G. The lead is partially converted into sulphate or carbonate, and is quite corroded away in patches of an inch or so, leaving the tarred fibre bare. The insulation, such as it is, which is afforded by the fibre does not seem to be affected, but, deprived of the protection of the lead, it is less serviceable than the "tape and tar" which was occasionally used eight or nine years ago. The lead, judging by its softness, appears to be pure.

IT is well known among architects that pure lead in contact with calic sulphate will be corroded, and that in contact with oak it will be attacked by the acetic acid present, and will be converted into white lead by carbonic acid. There is a temptation to use lead where the drawing on process of covering conductors is employed, and care should be taken to employ a suitable alloy. Mr. PREECE, in the Paper read before the Institution of Electrical Engineers, advocated the use of lead, and remarked that the lead pipes used by the Romans were still visible at Pompeii; adding that, when properly protected, lead ought to last for centuries. But the Romans did not trouble to extract the tin, antimony, and silver which exist in the crude metal, and it is probable that it is only when it is properly *alloyed* that "lead" will last for centuries.

THE arrangement of the Science Collection at South Kensington has many present inconveniences, and some of these it will be impossible to remedy if the new picture gallery be planted on the very spot where extension of the science schools could best be made. The largest Wimshurst machine in existence, which was presented by the inventor, can never be used for teaching purposes, since it is deposited upstairs, a quarter of a mile away from the lecture room, and is, of course, far too heavy to move about.

Metz.—The Metz Gas Company has arranged with the town authorities to establish an electric lighting central station, the motive power being obtained from the Moselle.

Obituary.—The death is announced, on Monday last, of M. Edmond Becquerel, who died in Paris, at the age of 71. We hope to give a full obituary notice of this distinguished *savant* in our next issue.

Electricity at the Chicago Auditorium.—There are 230 miles of electric wire and cables in this building. Current is supplied to 10,000 lamps and for other purposes by 11 dynamos, and 13 electric motors are used for driving fans.

Hampstead Vestry.—At a special meeting of this Vestry, last week, it was decided, after considerable discussion, to prepare a draft Provisional Order, and to inform the Board of Trade of the Vestry's decision. Mr. Preece attended and gave evidence.

Royal Society.—Among the Papers down for reading before the Royal Society, yesterday, was one by Captain Abney on "The Limit of Visibility of the Different Rays of the Spectrum. Preliminary Note," and another by Mr. J. Larmor, "On the Theory of Electro-dynamics."

Institution of Electrical Engineers.—A general meeting of the students of the Institution was held on Friday, May 8th, when a Paper was read on "Magnetism" by Mr. C. O. Lloyd. The next meeting will take place on Friday, May 22nd, when Messrs. Haig and Griffin will read a Paper on "Arc Lamps."

Boilers.—The experimental section of the Magdeburg society of boiler users communicates the fact that ordinary cement made into a stiff paste with water (so that it adheres to a vertical wall) is admirably adapted for closing the manholes of boilers, and holds the two surfaces well together. The cement becomes sufficiently hard in 8-12 hours, and can then be submitted to pressure.

Transmission of Power by the Rotating Current.—Schuckert and Co., of Nürnberg, who have for the past three years been carrying out experiments with the so-called rotating current field motors, have completed an installation for the transmission of 250 H.P. at Luisenthal, near Gmund. Of the total amount, 200 H.P. are transmitted by means of the rotating current.

Provisional Orders.—Another batch of Provisional Orders has been granted by the Board of Trade relating to Bromley (Kent), Preston, Scarborough, Torquay, Tunbridge Wells, Withington District, Edinburgh, Paisley, Hertford, Killarney,

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Kingston-upon-Thames, Liverpool, Toxteth Park, Whitehaven, Birmingham, Cardiff, Exeter, Ipswich, Whitby, Camberwell, Islington, Southwark, Wandsworth District, Westminster, City of London, Clerkenwell, Chelsea, Woolwich, Newport (Mon.), Poole, and Weybridge.

The Sims-Edison Torpedo.—The First Lord of the Admiralty was asked, last week, whether his attention had been called to the public trial of the Sims-Edison torpedo made at Havre, and whether he intended having experiments made with it at Portsmouth or elsewhere. It was stated in reply that no experiments would be carried out by the Admiralty, but that the trials had been attended by officers acquainted with the Brennan torpedo, and its capabilities, in comparison with that weapon, would doubtless be reported on and considered.

Telephone Trunk Wire Extensions in Scandinavia.—According to the *Elektrotechnische Zeitschrift*, Christiania and Stockholm, which are some 275 miles apart, are to be placed in telephonic connection. In Norway the line goes from Christiania to the border at Magnor. In Sweden the Stockholm-Orebro-Carlstad line will be used, the necessary extensions being made. This will place Christiania in communication with several towns in Central Sweden. For several hours each day the line will be reserved exclusively for speech between the two capitals.

German Electric Lighting Statistics.—From an inquiry instituted by the Government Department concerned with the telegraph and telephone services, it appears that there existed in the German Empire (exclusive of Wurtemberg and Bavaria) on January 1, 1890, 2,590 electric-light installations, comprising 339,000 incandescent lamps and 2,160 arc lamps. There were also nine installations connected with the electrolytic industry and 16 transmission of power plants. Some 86 per cent. of the lighting installations were supplied with continuous currents, 9 per cent. employed alternating currents, and 5 per cent. employed both.

Frankfort Exhibition.—The Grand Duke of Weimar has lent the Exhibition authorities the electric machine with which Goethe made his experiments, and which is included in the relics in the Goethe Museum at Weimar. The Congress of German Municipal Authorities, to be convened by the chief magistrate of Frankfort during the Exhibition, is to be held on August 27th, 28th, and 29th. The two electrical boats which will be on the Main during the Exhibition are to be accompanied by a boat propelled by a petroleum engine. The engine will also drive a small dynamo which will generate current for the lights.

Electric Traction on the West Metropolitan Tramways.—A Select Committee of the House of Commons passed a Bill on Wednesday extending the time for the completion of the West Metropolitan Tramways in Hammersmith, Chiswick, Acton, and Ealing, to August next year, and also obtaining powers to work the line by electricity. The only petitioners against the measure were the National Telephone Company, who, supported by the evidence of Sir William Thomson and Sir Frederick Bramwell, succeeded in obtaining the insertion of a clause compelling the tramway company to insulate their wires in such a way as not to interfere with the working of the telephone system.

The Electric Lighting of Westminster Hall.—Mr. Story-Maskelyne asked the First Commissioner of Works, last week, whether, considering the deleterious effect of the acid products of the combustion of gas on the ancient wooden roof of Westminster Hall, he would consider the advisability of substituting the electric light for the gaslights at present employed. It was stated in reply that the matter had been carefully inquired into, and that it had been found that at one spot the hammer beams in the roof of Westminster Hall had been blackened, though not charred, by gas lamps, which are placed some 15ft. or 20ft. below them. There was no ground for believing that any permanent injury had been done. Gas was being replaced by electricity throughout the Palace generally as rapidly as possible.

An Electric Crane.—An electric hoisting and conveying machine has recently come into operation at Cleveland, Ohio, and has been examined by prominent iron ore and coal shippers, and pronounced a success. A 30 H.P. electric motor is mounted upon a light tramcar holding suitable hoisting mechanism, and the operator riding on this car hoists the load from any desired point and rapidly conveys it to the place of unloading. The constant presence of the operator over his work has a great advantage over steam automatic cable systems in present use. The present work performed by the plant is unloading a vessel of iron ore, hoisting a load of 3,000lb. vertically 5ft. per second, then travelling across a bridge 30ft. high and 200ft. long, spanning the ore dock, the cross travel being made in 10secs., and the operator stopping the car, holding the bucket, and dumping the load at any desired point.

Hydrochloric Acid in Bichromate Cells.—Mr. Charles Steinmetz writes to the *Electrical Engineer* of New York to the effect that he has found a mixture of bichromate, sulphuric acid, and crude muriatic (hydrochloric) acid to be an excellent solution for use in the bichromate battery. After over half a day's continuous use with a very low external resistance, neither the E.M.F. nor the internal resistance was perceptibly changed. None of the cells got hot; neither was there any boiling over or formation of crystals on the zinc, but the battery ran steadily until the liquid showed the greenish-yellow colour of approaching exhaustion. In a subsequent issue, however, Mr. Charles J. Reed points out that the only advantage that can result from the use of hydrochloric acid is the evolution of chlorine at the expense of the chromic acid. The advantage of free chlorine in a battery seems to him doubtful, and its preparation by the action of a chromate on a chloride to be, at least, expensive.

Transmission of Power Plants by the Oerlikon Works.—The *Elektrotechnischer Anzeiger* gives the following list of power installations carried out by the Oerlikon Works:—

Place.	Horse-power transmitted.	Distance in miles.	Efficiency. Per cent.
Solothurn	50	5·0	75
Derenduigen	280	·8	80
Lugano	60	5·0	—
Bregenz	200	1·6	78
Schio	300	3·7	73
Lucerne	120	1·9	70
Schaffhausen	600	·4	75
Styrermühl	360	·4	80
Kematen	125	1·6	78
Mendoza.....	480	1·9	75
—	320	4·3	75
—	320	1·9	75

Overhead Wires at Sheffield.—Major Cardew has made a lengthy report with reference to the electric light overhead wires, and a copy of it has been forwarded to the Parliamentary Powers Committee of the Sheffield Corporation. Major Cardew reports that the insulation is dangerously insufficient, and he considers it utterly untrustworthy. A good system of testing is in use, and when the insulation shows any unusual leakage prompt steps are taken to remedy it. The careful system of testing and maintenance considerably diminishes the risks, but he cannot view the use of such wire in a crowded town without apprehension. The Parliamentary Powers Committee, on the receipt of this report, instructed the Town Clerk to write to the Sheffield Telephone Exchange and Electric Light Company, and inquire what they were doing with regard to matters mentioned in the report. They also passed a resolution expressing the opinion that it was desirable that all wires for the supply of electric light should be carried underground.

Faults on a Subterranean Telegraph Line.—In a recent number of the *Annales Télégraphiques*, M. Brylinski gives some particulars with regard to the extraordinarily faulty condition of the Tarare-Roanne section of the subterranean telegraph line running from Lyons to La Palisse, a distance of some 70 miles. The two end sections of the line consist of insulated cables run in cast-iron pipes, and these are in excellent condition. On the central or Tarare-Roanne section, 26 miles long, however, 394 faults were located, or over 15 per mile. This section was laid down in 1885, and consists of gutta-percha

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insulated cables run in cement conduits. Whole lengths of the outer insulation were found in a state of putrid decomposition, the braiding and taping had entirely disappeared, and the conduit was filled with a black pulp. The bare cores were covered with long yellowish-grey streaks, and it seems probable that these were patches of cement deposited on the gutta-percha by the water which is always to be found in the conduit. At these spots the gutta-percha was spongy and eroded.

Boilers Registration Bill.—The Engineering Trade Section of the London Chamber of Commerce at their meeting, held on April 22, 1891, after considering the provisions of this Bill, adopted the appended memorandum embodying the conditions which they consider should be observed in any legislation affecting the registration of boilers and designed to reduce the number of explosions arising from various causes. The Committee were of opinion that the Bill, if amended in accordance with their suggestions, would better effect the object which its promoters have in view. *Memorandum.*—1. That every boiler owner shall register his boiler or boilers at the Board of Trade, with particulars (as per the schedule to the Bill) of every boiler owned by him, together with full data and the name of his engineer or other person directly responsible for the condition and management of the boiler or boilers. 2. That the Board of Trade shall keep a register of all boilers and their owners and of the managers responsible for the same, and shall take proceedings against boiler owners who neglect to have them registered in due course. 3. That the Board of Trade may cause an examination to be made in the case of all explosions, and shall make such an examination in every case where explosion causes damage externally to the boiler or injury to life or limb, or both, and the Board of Trade shall prosecute the party or parties whom they consider to blame. 4. That the boiler owner shall pay a small fee to the Board of Trade to meet the expenses of registration and prosecution.

The Giraud Thermo-Electric Stove.—The process of transforming the thermic energy of combustion into electric energy actually and generally employed is certainly by far the most complicated of any, for it necessitates a passage through the intermediary of mechanical work; but it is undoubtedly the most economical in the actual state of science, and all efforts hitherto made to replace it have failed, owing to the low efficiency of the transforming apparatus, the thermopile. In fact, the most perfect thermopiles consume 30 litres (1.05 cubic feet) of lighting gas per watt-hour, or 30 cubic metres (1,050 cubic feet) per kilowatt-hour, which makes the price of electrical energy absolutely prohibitory from the commercial and even domestic point of view. The coefficient of transformation is less than five in a thousand, that is to say, less than one-half per cent. of the thermic energy of combustion is delivered to the external circuit available for use. But the problem, says M. Hospitalier in *Le Génie Civil*, completely changes its aspect if, instead of considering the electrical energy as the principal product of combustion, we consider it as an accessory or secondary product, the principal one being the heat which we can use in its integrity, with the exception of a few thousandths, in spite of the accessory product. From this point of view, M. Hospitalier is sanguine enough to think that something may be expected from the thermo-electric stove of Dr. Giraud, of Chantilly. This gives 30 or 40 watts permanently and regularly when consuming its usual quantity of combustible. The 800 to 1,000 watt-hours produced daily by the apparatus and stored in accumulators would enable one to run some 25 10 c.-p. lamps. The idea, therefore, deserves attention and investigation, thinks M. Hospitalier.

New Edison Central Station Plant.—The Edison Company of America are building a line of triple expansion engines coupled direct to multipolar dynamos, a machine being attached to either end of the main crank shaft. The steam pressure employed is 160lb. The generators mostly have 6 to 10 poles, with a ring armature revolving within a concentric circular field-magnet frame with internally projecting pole pieces. The frame of the field-magnet consists of a single casting. The Gramme ring type of winding is employed, but, instead of using coils of a number of convolutions connected to each segment of the commutator, each convolution is connected directly with the commutator bar. For this purpose bare U-shape copper strips are slipped over one side of the core, insulated from one another, and each succeeding U-shaped bar of this character is connected direct to a commutator bar. The brushes bear upon the commutator in a vertical plane. This construction with bare conductors is permissible on account of the very small difference of potential, 1¼ volt existing between each bar. The number of bars employed in this type of machine is 944. Each bar is, therefore, equivalent to a coil of the usual type of Gramme winding; but the absence of contiguous layers entirely avoids self-induction, and hence sparking, the machine operating without the slightest indication of such a disturbance. Several brushes are employed, which can be shifted simultaneously by means of a hand-wheel, and which can also be lifted at once from the surface of the commutator. This type of combined engine and dynamo, says the *Electrical Engineer* of New York, will probably be employed in the new Edison station in New York, where no less than fourteen 2-400 kilowatt generators will be placed. In the same way the Cincinnati station will be equipped with ten 2-400 kilowatt generators.

Royal Society Candidates.—Fifteen candidates were selected on April 30th by the Council of the Royal Society, to be recommended for election into the Society. The ballot will take place on June 4th. The work of the three following candidates has been mainly of electrical interest, and some of the statements of qualifications may be of interest.—Oliver Heaviside. Has applied higher mathematics with power and success to the developments of Maxwell's theory of electro-magnetic wave propagation, and has extended our knowledge of facts and principles in several directions and into great detail. He is the author of the following Papers among many others:—"On Electro-magnetic Induction and its Propagation" (48 parts, 1885-87, in *The Electrician*); "The Induction of Currents in Cores" (15 parts, 1884-85); "Some Electrostatic and Magnetic Problems" (5 parts, 1883); "Current Energy" (19 parts, 1883-84); "On the Electro-magnetic Effects due to the Motion of Electrification through a Dielectric" (*Phil. Mag.*, 1889); "The General Solution of Maxwell's Equations" (*Phil. Mag.*); "On Electro-magnetic Waves" (6 parts, *Phil. Mag.*, 1888); "On Resistance and Conductance Operators" (*Phil. Mag.*, 1887); "On the Self-induction of Wires" (7 parts, *Phil. Mag.*, 1886-87); "On the Electro-magnetic Wave Surface" (*Phil. Mag.*, 1885); "On the Electro-magnetic Effect of a Moving Charge;" "The Deflection of an Electro-magnetic Wave by Motion of the Medium;" "On the Working of Cells with Condensers" (*Phil. Mag.*, 1874); "On the Extra Current" (1876); "On the Speed of Signalling through Heterogeneous Telegraph Circuits" (*ibid.*, 1877); "On the Effect of Faults on the Speed of Working Cables;" "On Electro-magnets" (*Jour.* Soc. Tel. Eng.); "On Induction between Parallel Wires" (*ibid.*)—W. N. Shaw, Demonstrator of Physics in the Cavendish Laboratory at Cambridge from 1880 to 1887, and now University Lecturer in Physics, bore an important part in the organisation of the laboratory. A considerable part of the success of the Cambridge School of Physics is due to his exertions. Author of numerous Books and Papers.—Silvanus P. Thompson, Principal and Professor of Physics in the City and Guilds of London Technical College, Finsbury; formerly Professor of Experimental Physics in University College, Bristol. Author of many Papers, including the following:—"The Theory of the Magnetic Balance" (*Proc.* Roy. Soc., 1884); "Electro-deposition of Alloys" (*ibid.*, 1887); "Subjective Interference of Sound" (*Phil. Mag.*, 1887); "Opacity of Tourmaline Crystals" (*ibid.*, 1881); "The Meaning of the Constant in Bernouilli's Law of the Lifting Power of Magnets" (*Phil. Mag.*, 1888); "Development of the Mercurial Air Pump" (*Jour.* Soc. Arts, 1887); "The Influence Machine from 1788 to 1888" (*Jour.* Soc. Telegr. Engin., 1888). Author of a treatise on "Dynamo-Electric Machinery" (3rd edit., 1888), and of an elementary text-book of Electricity and Magnetism (43rd thousand, 1889), which has gone through many English and several foreign editions. Originator of improvements in polarising prisms, in the method of adjusting resistance coils, and in sundry electrical apparatus. Distinguished for his acquaintance with the science of electricity, more particularly in its experimental and technical aspects.

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EXPERIMENTS ON THE RATIO OF ELECTROSTATIC TO ELECTRO-MAGNETIC INDUCTIVE DISTURBANCE BETWEEN NEIGHBOURING TELEPHONE CIRCUITS.

BY A. E. KENNELLY.

The following experiments were made with the object of not only verifying the experimental results obtained by Mr. J. J. Carty, as stated in his recent interesting paper "On Inductive Disturbances in Telephone Circuits,"* read before the American Institute of Electrical Engineers, but also to check within fair quantitative limits the deductions from those results by reference to theory.

It would seem that both these aims have been reasonably fulfilled. Some 305 metres (1,000ft.) of double conductor, gutta-percha cable of dimensions shown in the diagram, were

FIG. 1.
Section of Cable (Full size).

Dimensions :—
Inner Strand—
7 copper wires each 0·025″ (0·064 cm.) diam.
Strand diameter 0·102″ 0·259 cm.
Diameter of g.-p. core 0·175″ 0·445 cm.
Outer Strand—
18 copper wires each 0·036″ (0.091 cm.) diam.
Strand diameter 0·247″ 0·627 cm.
Diameter of g.-p. core 0·370″ 0·940 cm.
Diameter over braiding 0·425″ 1·08 cm.
Conductor, resistance of inner strand 2·42 ω at temp. of test (12°C).
" " outer " 0·5 ω " " "

laid out on the ground in a figure roughly representing a complete rectangle of sides 30, and 120 metres in length. The cable thus afforded two complete and independent circuits by the interior and exterior copper strands, the insulation between which was 20,000 megohms at the end of one minute, and their mutual electrostatic capacity 0·075 microfarad, from measurements taken at the time. The insulation of the outer strand to ground was about 4,000 megohms. The interior conductor was used as the primary or inducing circuit, and the exterior conductor as the secondary or recipient circuit. The transmitter or source of disturbance was a continuous current dynamo giving 125 volts as its terminals (shunt wound), supplying about 50 amperes to incandescent lamps, and with one side grounded. A simple harmonic variation of electromotive force would, of course, be preferable for quantitative measurements, but there is some experimental difficulty in creating such a variation having the necessary frequency, while if the pure sine wave of disturbance is relinquished, and the exact shape of the wave is neglected, a dynamo becomes a

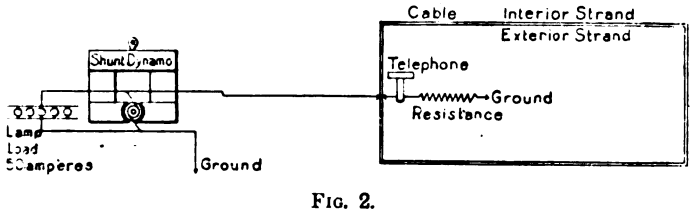

FIG. 2.

very convenient transmitter. The small fluctuations in its E.M.F. produced by the successive reversal towards the external circuit of each armature coil as it passes under the brushes, are periodic variations whose frequency will be equal to the number of bars passing under each brush per second; and, conversely, it is only necessary to join a telephone across the mains of a continuous current circuit (through protecting resistance of say 10,000 ω), to hear a note in the telephone† whose frequency corresponds to the number of commutator bars passed over in one second by one brush. A trained musical ear will often identify this note, and thus the frequency, very closely, and the principle may be practically useful for distinguishing circuits operating at the same continuous presure, but served by generators of different type, or to ascertain the speed of the dynamo armature when the number of its commutator bars is known. In this instance, the telephone note was identified by the use of Helmholtz resonators as nearest to c''' of 1,300 ∿. By measuring the revolution speed of the armature, the number of bars passing under the brush per second was 1,257. This number was, therefore, taken as the frequency of the periodic disturbance in these experiments. Various combinations of the two cable circuits were tried, so as to obtain electrostatic induction only, electromagnetic induction only, or both together. Of these the two most important cases bearing on the question are shown in the accompanying diagrams. Fig. 2 shows the arrangement of circuits in which electrostatic action is almost wholly active, and Fig. 3 the case in which electrostatic induction is negligible, electro-magnetic induction being displayed to fullest advantage.

Referring to Fig. 2, the dynamo is connected directly to the interior conductor, while the exterior is connected to ground through a Bell telephone having a resistance of 73 ohm, and an inductance of 113 *h*. The dynamo note was heard in this telephone. The effect was not due to leakage, because a battery of 50 volts replacing the dynamo, and working through an interruptor, produced no sound. The disturbance was, therefore, accepted as wholly electrostatic. It required a very large resistance in circuit between the telephone and ground to bring the note down to the limit of audibility. With resistances of graphite, the amount needed to reach this limit was found to lie between 2 megohms and 10 megohms. It was estimated at 7 megohms.

In Fig. 3, the dynamo is shown connected through a galvanometer and bank of lamps to the interior conductor of the cable, the other end of which is grounded. The only appreciable inductance in this primary circuit is in the dynamo

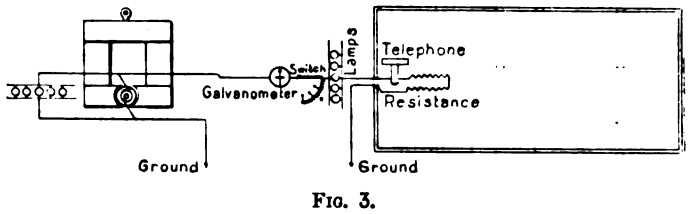

FIG. 3.

armature. Inductance is capable of being inserted between the galvanometer and lamps at will. The outside conductor completes its own circuit, insulated from the ground, through the telephone and resistance. Corresponding to different strengths of current in the primary circuit, resistance is added in the secondary circuit to bring the sound in the telephone down to the limit of audibility.

The results are given in the following table :—

Current in primary circuit.	Resistance in primary circuit.	Inductance added to primary circuit.	Impedance in primary circuit.	Resistance in secondary circuit.	Inductance in secondary circuit.	Impedance in secondary circuit.	$\omega_1\ \omega_2$
Amperes.	Ohms.	Millihenrys	Ohms.	Ohms.	Millihenrys.	Ohms.	(Ohms².)
0·522	239·7	—	240	80,000	113	80,000	$1·92 \times 10^7$
0·742	169	—	169	110,000	,,	110,000	$1·86 \times 10^7$
1·419	88	—	88	200,000	,,	200,000	$1·76 \times 10^7$
2·608	47·9	—	47·9	400,000	,,	400,000	$1·92 \times 10^7$
2·774	45·1	4·96	59·7	110,000	,,	110,000	$6·57 \times 10^6$
2·868	43·6	37·9	302·5	20,000	,,	20,000	$6·05 \times 10^6$
2·608	47·9	0	47·9	400,000	,,	400,000	$1·92 \times 10^7$

The first column gives the observed steady currents in the primary circuit, from which, since the pressure was 125 volts, the resistances in the second column are found. The third column gives the inductance (in coreless coils of copper wire) added to the primary circuit, and from these, with a frequency of 1257 ∿, the impedance inserted in the primary circuit to the variations of its E.M.F. are given in column 4. In No. 5 appear the resistances added to the secondary circuit in order to quench the dynamo note in the telephone; and since the only appreciable inductance in the secondary circuit was that of the telephone, negligible in series with the large resistances, the impedances of column 7 are only repetitions of these re-

* See *The Electrician*, Vol. XXVI., April 10, p. 705.

† An arc lamp will sometimes emit the same note apparently from its "crater."

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sistances. The last column gives the product of the primary and secondary impedances. This value is nearly uniform except for the cases in which inductance is added to the primary circuit. The marked discrepancy in these two cases is, perhaps, due to the shunting action of the load circuit supplied by the dynamo, which, being nearly inductanceless, would reduce the periodic current in the primary circuit below the calculated amount, in about the ratio here represented. For the same reason the inductance of the dynamo armature (about 0·3 h) has not been taken into account. It appears, however, probable from an inspection of the results, that with a resistance of 7 megohms in the secondary circuit, it would be necessary to reduce the primary circuit resistance to about 3 ohms., in order to just render the dynamo note audible in the telephone. The dynamo in these experiments was at a distance of about 250ft. from the telephone, and silence was obtained in every experiment as soon as the wires leading to the dynamo were disconnected from the primary circuit.

We may now check these results by calculation. The check can only be a rough one, because we shall have to assume that the periodic variation of E.M.F. is a simple harmonic function of time, and that the inductance of the dynamo armature is negligible.

Let e be the E.M.F. generated by the dynamo at any instant.
" K " " mutual electrostatic capacity of the two circuits.
" M " " mutual electro-magnetic capacity of the two circuits.
" p " " pulsation of the periodic variation of E.M.F. $(2\pi n)$, $n = 1257$.
" γ_c " " current in the secondary circuit at any instant in Fig. 2.
" γ_m " " current in the secondary circuit at any instant in Fig. 3.
" ω_1 " " impedance of the primary circuit.
" ω_2 " " impedance of the secondary circuit.
" r_2 " " resistance of the secondary circuit.

All expressed in Absolute El. Mag. Units.

Then in Fig. 2 :—If no resistance existed in the secondary path to ground, we should have

$$\gamma_c = -K\frac{de}{dt} = -pKE\cos pt \quad . \quad . \quad . \quad (1),$$

where E is the maximum ± periodic variation of e, but with resistance r_2 inserted as shown, the current becomes very nearly

$$\gamma_c = -\frac{E}{r_2}\cos pt \quad . \quad . \quad . \quad . \quad . \quad . \quad (2).$$

In the case represented by Fig. 3, we have

$$\gamma_m = -\frac{de}{dt}\frac{M}{\omega_1\omega_2} = -\frac{pME\cos pt}{\omega_1\omega_2} \quad . \quad . \quad (3),$$

and

$$\frac{\gamma_c}{\gamma_m} = \frac{\omega_1\omega_2}{pr_2M} \quad . \quad . \quad . \quad . \quad . \quad . \quad (4).$$

Also, since γ_c was adjusted to estimated equality with γ_m, we should have

$$\omega_1\omega_2 = pr_2M \quad . \quad . \quad . \quad . \quad . \quad . \quad (5),$$

where $\omega_1\omega_2$ was $1{\cdot}9\times10^{25}$
r_2 " 7×10^{15}
p " $7{\cdot}9\times10^3$,

and M calculated for two circuits forming a rectangle of 12,000 × 3,000 cms. is nearly $2{\cdot}0\times10^5$

$$\therefore\ pr_2M = 1{\cdot}1\times10^{25}.$$

The two members of equation (5) were thus experimentally of the same order, although the agreement is by no means close.

It may be fairly concluded that when two insulated wires run parallel and close together, a periodic E.M.F. acting on the circuit of one is liable to induce disturbances in the other, of which the greater part will be due to electrostatic effect unless the product $\omega_1\omega_2$ is less than the ratio of their electromagnetic to their electrostatic mutual capacity.

For parallel copper wires suspended at the same height above ground, this ratio is in Absolute El. Mag. measure.

$$\frac{M}{K} = 3{\cdot}6\left\{\left(\log_\epsilon\frac{2h}{r}\right)^2 - \left(\log_\epsilon\sqrt{1+\frac{4h^2}{d^2}}\right)^2\right\}\times10^{21} \quad (6),$$

where r is the radius of each of the wires (in centimetres).
" d is the distance between their axes "
" h is their common elevation above ground "

This ratio increases with the intervening distance d, so that the closer the wires the greater the electrostatic effect. The maximum value the ratio can attain under practical conditions is about 5×10^{23}, so that the product of the impedance in ohms of the primary and secondary circuits should not exceed 500,000 if magnetic induction is to be in the ascendant. Thus, if the primary circuit has 1000 ohms impedance the secondary should not have more than 500 ohms.

The particular pair of circuits experimented with in this case favoured electrostatic action more than would be usually the practice of overhead circuits, for the ratio M/k was only $2{\cdot}67\times10^{21}$, making the limiting ohmic product of the two circuits 2,670, while M/k is commonly about 2×10^{23} for a pair of pole lines, increasing the range of the ohmic product to 200,000. It is also to be observed that when the impedance in the primary circuit is small, and especially when it is situated at the transmitting end of the line, the variation of electrostatic potential, and, consequently, induction, will be greatly reduced, and the above rules for estimating the proportion of static and magnetic disturbance only approximate the truth when the impedance of the primary circuit is large, and particularly when situated at the receiving end of the line. As the lengths of the circuits increase, the greater will be the electrostatic share of disturbance, all other conditions remaining constant.

It is remarkable how small a mutual electrostatic capacity suffices to establish audible telephonic inductive disturbance of static nature, between two conductors. In fact, when the resistance to ground of the secondary circuit happens to be very high, the disturbance due to a small mutual static capacity would be hardly and often inappreciably increased if the two circuits were collected metallically.

For

$$\gamma_c = \frac{K\frac{de}{dt}}{\sqrt{1+p^2K^2r_2^2}} \quad . \quad . \quad . \quad (7),$$

and when r is more than ten times $\frac{1}{pK}$ this becomes very nearly

$$\gamma_c = \frac{pKE\cos pt}{pKr_2} = \frac{E\sin\left(pt+\frac{\pi}{2}\right)}{r_2} \quad . \quad . \quad (8),$$

and this is the strength of current that would be set up in the secondary circuit if the E.M.F. acted upon it directly.

As an instance of this, it was found that if the dynamo above mentioned were connected directly with the telephone through a condenser of 0·001 microfarad, and a resistance of 2·5 megohms in simple series, the clearly audible dynamo note was not appreciably strengthened by short circuiting the condenser. In fact, substituting these values in the last equation with $7{\cdot}9\times10^3$ for p, the ratio of the current without condenser to that with condenser in circuit is 1·0015 on the assumption of a pure sine variation of E.M.F. The same result should have followed with a condenser of only 0·00016 microfarad, allowing a ratio of 1·05 between the two currents as the limit of audible appreciation. This experiment can be verified with any dynamo and a few feet of gutta percha covered wire lying on the ground as a condenser and a graphit resistance in circuit with the telephone, after precautions are taken to ensure the necessary degree of insulation in the wire and instruments.

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THE HELLESEN DRY CELL.

BY SHELFORD BIDWELL, F.R.S.

The following results of some practical tests of the new Hellesen dry cell, which I made for my own information, may probably be of general interest.

The experiments were made with 12 cells of the No. 2 type, measuring 3 × 3 × 6½in., as manufactured by Messrs. Siemens, Brothers and Co. The most striking characteristics of these cells, as distinguished from others of the same class, or, indeed, from any other primary battery that I know of, except those of the Bunsen and Grove type, are their small internal resistance and comparative freedom from polarisation. The cells were successively connected, each for a few seconds, with a galvanometer, the resistance of which, together with that of the leads, was about 0·005 ohm. The greatest current indicated was 12·9 ampere, the smallest 11·9, the mean for the 12 cells being 12·35. The E.M.F. at 17°C., in comparison with that of a standard Clark's cell, the E.M.F. of which at that temperature was taken to be 1·438 volt, ranged from 1·41 to 1·50 volt, the mean being 1·47 volt. Hence it appears that the mean internal resistance of a cell, when circuited through 0·005 ohm, is (assuming the E.M.F. to be unchanged) as low as 0·114 ohm. To find the resistance when little or no current was passing, the copper terminals of two cells were joined together, and the resistance of the opposed pair determined by the telephone bridge method. This was found to be about 0·196 ohm, or 0·098 ohm for each cell.

Six cells were circuited with an 8-volt 2½ c.p. lamp, which they brought to full incandescence. The current at starting was 1·02 ampere, falling in the course of two minutes to 0·95 ampere, a fall of about 7 per cent. The circuit was then broken, and when again closed, about 5½ hours afterwards, the current indicated was 1·01 ampere. For comparison, the same lamp was joined up with a battery of six bichromate cells, each of one gallon capacity, the zincs being immersed just so far as to give at starting a current of as nearly as possible 1·02 ampere. In two minutes the current had fallen to 0·8 ampere, a decrease of more than 20 per cent., nearly the whole of which occurred during the first minute.

One of the Hellesen cells, which had been previously used for several experiments, was connected with the galvanometer (resistance 0·005 ohm, including wires), and gave at first 12·2 amperes. In four minutes the current was 8·1 amperes, and in 11 minutes it had fallen to just half its original value, being only 6·1 amperes, when the cell was disconnected. The total output during the 11 minutes was calculated to be 1·4 ampere-hours, or 84 "ampere-minutes." After 45 minutes' rest the cell was found capable of giving 8 amperes, and two days later it gave 9·5 amperes, its E.M.F. having fallen from its original value of 1·41 to 1·35 volt, and its resistance on short circuit increased to nearly 0·14 ohm. Two days' further rest enabled the cell to generate 10·2 amperes; the E.M.F. appeared to have remained steady at 1·35 volt; the resistance must therefore have fallen to about 0·13 ohm. Of course no dry cell could be expected to bear such severe treatment with absolute impunity, and the small extent to which it suffered must be regarded as very satisfactory.

A single cell was competent to heat half an inch of No. 36 iron wire to bright redness; two cells instantly fused the wire. With one cell a small induction coil, having a secondary of 1,400 ohms, gave a half-inch spark, and with two cells a three-quarter inch spark, the longest for which the coil is intended. Other trials of a like nature need not be particularised.

To those who, like myself, are in the habit of working with electricity, and have not ready access to a dynamo and set of accumulators, these cells are likely to be of great value. One often requires for a brief period a current of greater constancy and strength than can be generated by bichromate or Leclanché cells, and I have many times had to go through the tedious and disagreeable operation of setting up and discharging a battery of Groves for the sake of obtaining current the total duration of which has not exceeded one or two minutes, or sometimes even a few seconds. In cases where a current of moderate strength, up to one or two amperes, and of fair constancy, is needed for a short time, the Hellesen battery seems capable of supplying all that is desired at a moment's notice and without any trouble. Outside the laboratory it can be employed for lighting small incandescent lamps, such as are used for surgical and microscopic purposes, or for seeing the time by a watch at night. It will work small motors and induction coils, and many other useful applications of it will suggest themselves. The advantages afforded by its cleanliness and portability need not be dwelt upon.

As to the life of the cells I cannot yet speak from experience. Other experimenters have stated it to be of long duration.*

ANDREWS' SYSTEM OF CONCENTRIC WIRING.

After an experience extending over several years, during which many experiments and different methods have been tried, Mr. J. D. F. Andrews has now brought his system of concentric wiring to a very satisfactory state of development. While having some points in common with the interior conduit system, which is so much spoken of in America, concentric cables for general wiring have rarely been used in this country, although a somewhat similar arrangement has been adopted for ship lighting.

One of the advantages claimed is safety against fire risks, since it is impossible to get at the inner conductor accidentally. Any leak must speedily result in a short circuit, and cannot give rise to charring of wood casing, &c.; but the essence of the system is that the external conductor affords a good mechanical protection to the inner one, and, except in very damp situations, no external insulation being used, the outer conductor is therefore practically earthed.

For this reason, and on account of the fact that the jointing of concentric cables is an operation which requires special care, the use of Mr. Andrews' system has been very considerably impeded, for engineers are, on the one hand, disinclined to employ a system to which their workmen must be specially educated, and, on the other hand, supply companies are too ready to throw the onus of maintaining a proper insulation upon their customers. At present, any one consumer's circuit is liable to be put to earth through the carelessness of another consumer or of the supply company itself, and for this reason there may be some hesitation in adopting a system in which the insulation of one pole is entirely dispensed with.

The Andrews system, however, possesses very important advantages, and has been thoroughly worked out, having been carried out in a most systematic manner, even to the design of special cut-outs and switches, where the advantages of the concentric principle are not so obvious. For the wiring of ships, dye-houses, mines, and under other difficult conditions, the system is particularly suitable. It has hitherto been employed chiefly by Mr. Andrews' firm, but we learn that several other firms have begun to adopt it. Owing to pressure on our space, we can only mention the following essential points in the construction of the cables and their uses.

They consist of a copper central conductor with vulcanised india rubber insulation, and armoured with galvanised iron wires, the latter forming the outer conductor. The cross sectional area of this armouring is usually made seven times that of the central conductor to maintain the same resistance in both. When the cables are larger, the armouring, or outer conductor, has to be laid on in two layers, in order to secure sufficient sectional area without increasing the diameter of the whole excessively.

The smaller sizes may, if required, be reduced in diameter to ¼ inch by using a copper outer conductor as well as an inner. When the wires are laid in plaster in the walls, the outer conductor is covered with a bituminous compound and yarn, for protection against any possible acids; beyond this no protection is used or required. An idea of the wiring may be gathered from the fact that the diameter of a wire to carry five lights is $\frac{5}{16}$ in., which takes the place of a wood casing measuring 1½in. × ½in., and larger cables are even smaller in proportion.

* See a report of some exhaustive tests which were made in the Physical Laboratory of Munich University, *The Electrician*, Vol. XXVI. p. 419.

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The jointing of two lengths of wire together, or of a branch wire to a main, was a matter of considerable difficulty with concentric wiring before the introduction of Mr. Andrews' method. After preparing the place for a joint by cutting away the outer conductor and tapering the insulation from both sides, so as to expose the central conductor, the inner conductor of the branch, being previously prepared in the same way, is joined on and soldered. The insulation is then lapped on, first, a layer of pure rubber; second, an intermediate layer or separation of india rubber and soapstone; third, a lapping of india rubber mixed with sulphur. The joint thus prepared is lapped over with selecia cloth, and copper sheaths are placed over the spaces cut in the outer conductor. An iron mould is then held round the joint by screws, and molten metal fusible at a low temperature is poured in at a suitable gate; the mould when cold is removed, and the joint is complete. This method of making a good outer conductor by means of a copper sheath is most effectual, the parts of the joint are completely soldered together, and the heat thoroughly vulcanises the india rubber of the joint. Joints such as these are not only better than the old cast-iron or brass boxes, but are much cheaper, and as easily made.

SUB-STATION REGULATING APPARATUS.

A transformer sub-station regulating apparatus, the invention of Mr. Thomas Tomlinson, chief engineer of Messrs. Gordon and Co., is represented in Fig. 1. The requirements of a practical apparatus for the automatic control of transformer sub-stations are as follows:—First, it must use mechanical and not mercury contacts; second, it must be able to make and break circuits carrying the heaviest currents without any sparking whatever; third, if any one of the switches accidentally becomes heated it must at once be short circuited and thrown out of action; fourth, if any accident or breakdown whatever occurs to the apparatus, every transformer must at once be put into circuit. This condition is absolutely essential, and is the most important feature of the new apparatus.

If an apparatus such as we are describing fails while taking transformers out of circuit no harm is done beyond a waste of coal, but if a failure were to occur when putting them into circuit it would probably cause a fire and the destruction of the sub-station. This apparatus is intended to entirely guard against this source of failure.

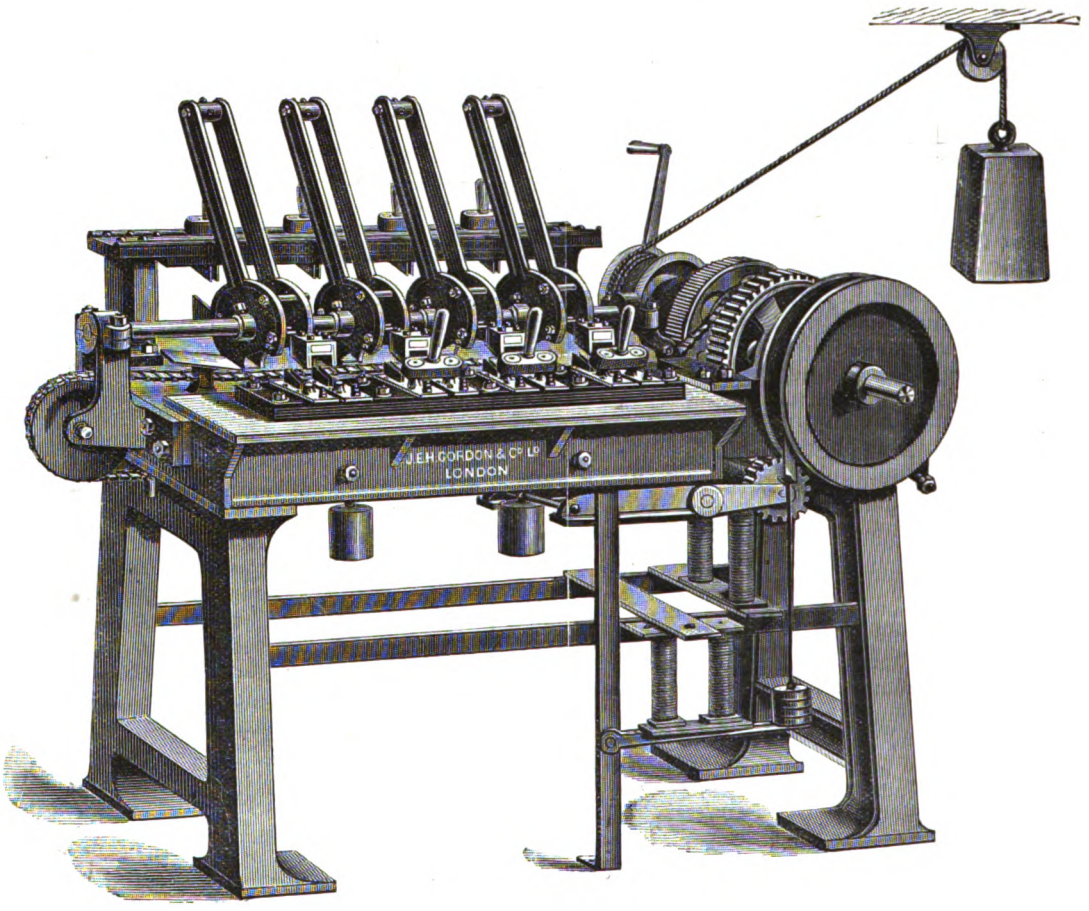

Fig. 1.

Four sets of switches are provided, and the transformers are arranged in five groups. One group is permanently connected to the mains and one more is connected through each set of switches respectively. The transformers are grouped as shown in Fig. 2. Suppose that one transformer is permanently connected to the mains, then one would be connected to the first switch, two to the second, four to the third, and eight to the fourth, so that the putting in of each switch doubles the number of transformers in circuit.

The switches are arranged to break the primary and secondary circuits simultaneously. The extra currents produced being in opposite directions, all sparking is prevented. With a load of 1,500 lamps on a single switch no spark whatever is visible. The switches are thrown over by a sliding carriage in the form of a double wedge, which runs backwards and forwards along the bed-plate of the machine, and, as it passes each switch, throws over a tumbling lever which strikes the switch suddenly in or out of contact. This carriage is moved by an endless chain actuated by two weights which are released respectively by two electro-magnets. The large weight which

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takes transformers out of circuit has to be wound up once a week, and, as it takes out the transformers, it at the same time winds up a smaller weight ready to put them in again. If any failure whatever of the large driving weight occurs, or if the attendant forgets to wind it up, the small weight is always ready to put the whole of the transformers into circuit, and must do this before the apparatus becomes inoperative.

The wheels seen in the illustration are in gear with each other, through the pinions, and the whole system is kept at rest by the brake seen at the far side of the machine. When a current is sent through the lower magnet this brake is released and the large weight falls, turns the spindle, and through the cogwheels draws the carrier back and takes switches out. At the same time it winds up the small weight,

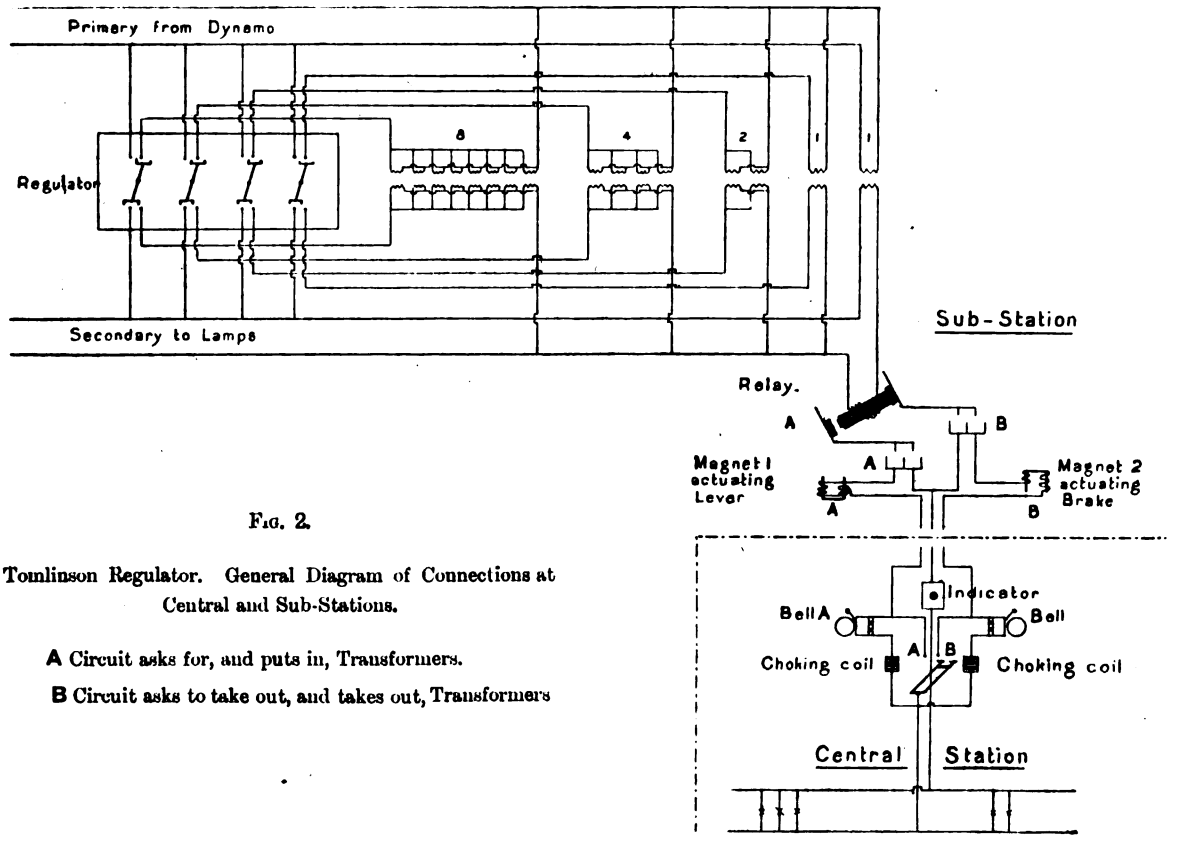

Fig. 2.

Tomlinson Regulator. General Diagram of Connections at Central and Sub-Stations.

A Circuit asks for, and puts in, Transformers.

B Circuit asks to take out, and takes out, Transformers

leaving it ready for putting the switches in again at any time. In case any switch should get hot, it would be short-circuited by the cross-pieces seen in Fig. 1 and shown in section in Fig. 3. These consist of hollow brass boxes mounted on an insulating frame, each box being electrically connected to a rod projecting inside the other box. Each box is lined with paraffin wax and filled with mercury. In case of heating, the paraffin melts and floats to the top of the mercury, which establishes a contact, and puts the switches out of action and puts transformers into circuit.

The method of actuating the apparatus is seen in Fig. 2. A double relay is provided, placed in the secondary circuit of the fixed tranformers. As soon as the current exceeds full load a contact is made, and a small current is sent through one of the magnets of the apparatus along a wire to the central station, where it passes through a choking coil and a bell. On the bell ringing, the attendant knows that more transformers must be put in, and he puts down a switch, which short circuits the choking coil and bell, and allows a sufficient current to pass to actuate the magnet and put a sufficient number of switches in. If the attendant should inadvertently hold down his contact-key too long the mistake will be corrected by the apparatus, as the circuit will break at the relay, and the machinery will cease to act. The magnet for taking out transformers is actuated in a precisely similar manner by the other part of the relay which acts when the current in the fixed transformers falls to less than half load.

In order to test this apparatus, a plant of 1,950 8 c.p. lights' capacity was, by the courtesy of the Brush Company, erected in their works, and connected to transformers kindly lent for the experiment by the Metropolitan Electric Supply Company. The plant was first run for 24 hours with the transformers connected in the ordinary manner, and then for 24 hours with them connected through the Tomlinson regulator, and coal and water were measured throughout the experiments. A preliminary experiment was made to find the coal used in running the engine, countershafting, and dynamo light, and this quantity was deducted. The electrical load was varied according to the ordinary requirements of the London stations (what is known as a 12·2 load factor being employed). The net result of the experiment was, that with the new apparatus 12¼ cwts. of coal were used in the 24 hours, and without it 16½ cwts., showing a saving of 26½ per cent. of the coal. From this Messrs. Gordon and Co. calculate that the saving amounts to 89lb. of coal, or in money to 10½d. per lamp per year. The average capital expenditure of a Supply Company is about £2. 5s. per 8 c.p. lamp, and this saving of 10½d. is, therefore, equal to 1¾ per cent. per annum on the capital which would be available to increase the dividends of the Supply Company. It must, however, be remembered that the conditions of the experiment, so far as the engine was concerned, were not those of actual central station working, where, if running at all, the engines are usually nearly fully loaded.

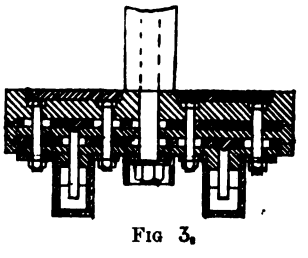

Fig 3.

Messrs. Gordon and Co. have published some rather intricate diagrams relating to the capital expenditure required for carrying out this system. They take a "lamp density" of one 8 c.p. lamp per yard run, which they say is an average pioneering density in London. Other curves represent densities of two

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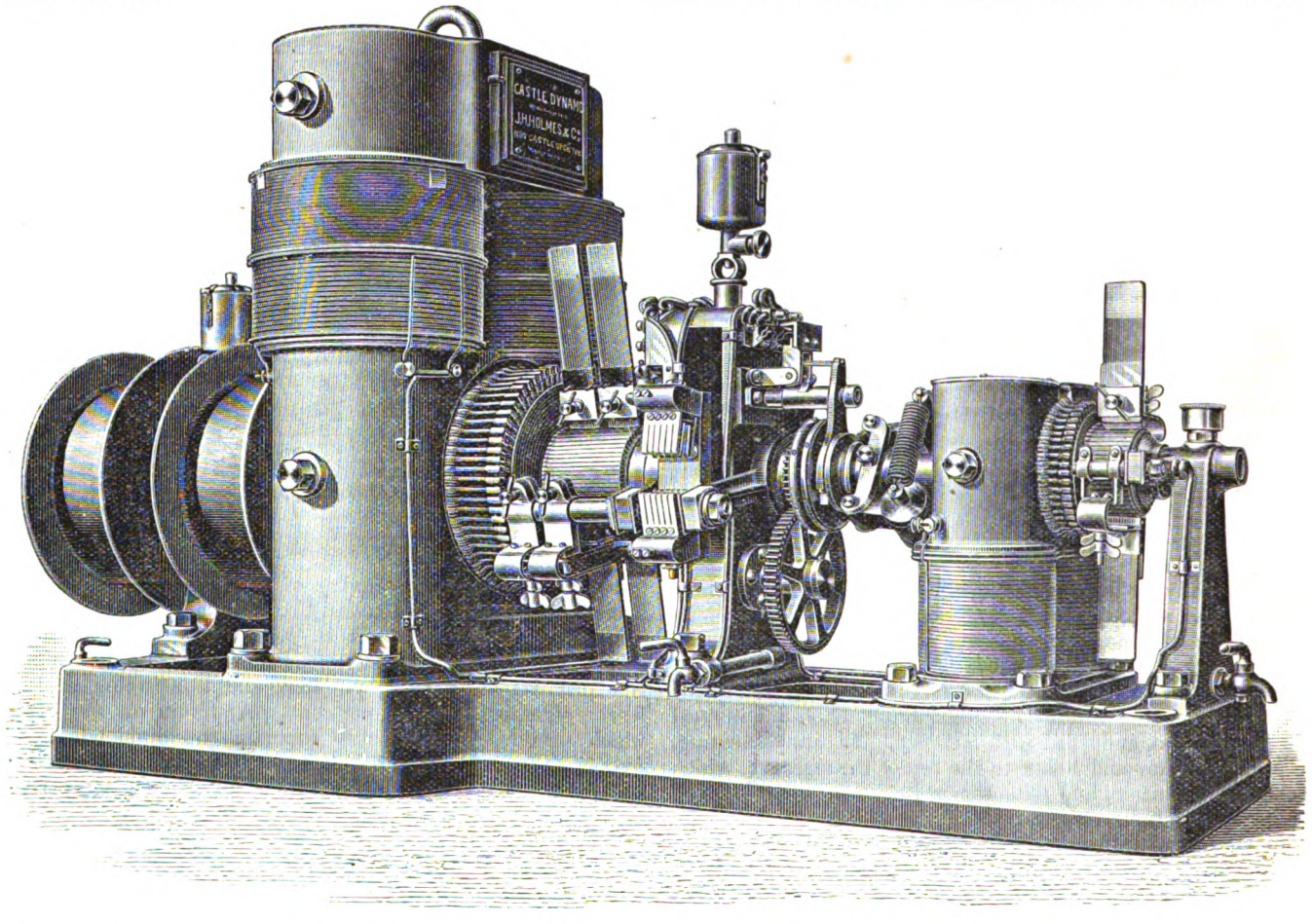
and four lamps per yard respectively. The figures show that with a pioneering density the capital cost, on the system under consideration, is about 5 per cent. dearer than that of the scattered transformer system, and that with all increased densities the capital cost is less.

They recommend that mains be laid with the sub-stations half a mile apart for pioneering, and that by afterwards inserting intermediate sub-stations so that they may be quarter of a mile apart, the same mains will serve when the density of supply is quadrupled.

The curves show that the position of the sub-station can be shifted for 200 yards without sensibly increasing capital cost, and thus some latitude is allowed in the selection of a site. These curves assume the lights to be approximately evenly distributed, but it should be noted that the existence of a large theatre or other public building at one point on the main would not affect the general calculations, as, if such a building were large enough to disturb the calculations, it would have a sub-station to itself.

J. H. HOLMES' RAILWAY TRAIN LIGHTING DYNAMO.

The accompanying illustration represents the improved Train Lighting Dynamos manufactured by Messrs. J. H. Holmes and Company, of Newcastle-on-Tyne, and 17, Coleman-street, London, E.C. This apparatus is being employed by the Midland Railway Company, more especially in connection with the electric lighting of their express trains. Mr. William Langdon, of Derby, explained its action very fully in his Paper read at the recent meeting of the Institute of Civil Engineers. It has also been supplied for French, German, and Russian railways.



The apparatus is the invention of Mr. J. H. Holmes, of Portland-road, Newcastle-on-Tyne, and is constructed with the object of maintaining a constant difference of potential at the terminals of the dynamo under a considerable variation of speed, and when driven in either direction. It depends upon the following principles, viz.:—Practically speaking, the volts of an ordinary separately excited dynamo vary directly as the speed at which the armature revolves; so, therefore, if the speed be increased, say from 500 revolutions per minute to 1,000 revolutions per minute, the electromotive force will be doubled. Also the electromotive force varies directly as the strength of the magnetic field, so that if the strength of field of a separately excited dynamo be reduced in the same proportion as the speed at which its armature revolves be increased, then the electromotive force of the armature will remain practically constant.

To this end two dynamos are arranged side by side, having their armatures upon the same shaft, so as to revolve together, main but with separate magnetic fields. The one is the generating machine, the other is for regulating the strength of the magnetic field of the generating armature. The magnets of the machines are separately excited from an external source, such as a set of accumulators, and the magnets of the generating armature are provided with two distinct exciting circuits. One circuit is an ordinary high resistance shunt circuit, and the other is of less resistance, and is coupled up to the source of current, so as to have the small regulating armature in series with it. The regulating armature is so coupled up that its electromotive force opposes the electromotive force of the external source of supply.

The high resistance shunt circuit is so proportioned that, at the highest speed at which it is intended to run the generating armature, it, without the aid of the regulating circuit, will give a magnetic field suitable for the required volts in the generating armature. When thus driven, the second exciting circuit ought to have no current passing

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through it, a result which is brought about by the volts of the regulating armature being, at its highest speed, equal and opposite to the external pressure. If, however, the speed falls the volts of the regulating armature are lessened in the same proportion, and, being no longer equal to the external volts, a current will be permitted to flow through the second exciting circuit of the magnets of the generating armature, thus increasing the strength of the magnetic field to make up for reduction of speed, with the result of maintaining practically uniform volts in the generating armature.

When the speed falls to the lowest limit, say half the highest speed, the volts of the regulating armature will be half the volts of the external source of supply, so that it will be seen that it is necessary to calculate the proportions of the second exciting circuit of the generating armature magnets upon the basis of only half the electric pressure of the external source being available, and the resistance of the regulating armature forming part of the circuit resistance. At the lowest speed, therefore, half the exciting power upon the generating armature magnets will be produced by one coil having the full difference of potential of the external voltage at its terminals, and the other half by the second and lesser coil having half that difference of potential at its terminals, less, of course, by the drop of potential due to the resistance of the regulating armature which forms a portion of this circuit.

As arranged for use on a railway train, the armature is driven by belting from the axle of the guard's van, and a set of accumulators furnish the current for exciting the field-magnets. A centrifugal governor on the armature spindle automatically switches on the storage batteries for exciting the magnet coils of both the exciting and regulating machine as soon as the speed rises to the minimum speed at which the dynamo is intended to come into action, and it in like manner also switches off the current when the speed falls below the minimum speed. As the dynamo has to produce current when the train is running in either direction, the brushes which collect the current from the two armatures are made of wire gauze and are placed radially to the commutators, and the "lead" being automatically altered to meet the direction of rotation, the connections to the armatures are at the same time changed, so as to keep the polarity of the dynamo terminals always uniform. On the spindle carrying the armatures is also arranged a reversing switch which is actuated by friction discs which come into friction when the spindle slows down, but which run free on its attaining any degree of speed. The duty of this reversing switch is to insure correct polarity of current.

Working in conjunction with the dynamo is an automatic switch, such as is generally used in electric light installations having two coils, one, the highest resistance coil, connected to the dynamo terminals, and the other, the low resistance coil, in the main lighting circuit. The duty of this instrument is to switch on the dynamo when its pressure is sufficient to overcome the voltage of the accumulators and to charge them.

ON THE MEASUREMENT OF POWERFUL CURRENTS WITH A MIRROR-GALVANOMETER.*

BY A. OBERBECK.

By the principle adopted by the author, "the most powerful currents, without the addition of any shunt, give such small deflections that they can be measured with a mirror-galvanometer." A circuit of small radius surrounds a small magnet needle placed at or near the axis of the circle, and deflects the needle more strongly than a second circuit of which the radius is greater. The two circuits being placed concentrically in the same vertical plane, they can be shifted to such a distance from the needle that their influences on it are equal, and if the directions of flow are opposite the needle will remain in its normal position. By placing the circuits at a distance from the needle suitable to the strength of the current to be measured, the desired small deflection can be obtained.

* *Wied. Ann.*, Vol. 42.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

FRIDAY, May 15th.

FINSBURY TECHNICAL COLLEGE.

7.30 p.m. Students' Conversazione.

JUNIOR ENGINEERING SOCIETY.

8 p.m. Ordinary Meeting. Paper to be read and discussed: "Electrical Storage Batteries," by H. B. VORLEY, A.I.E.E.

ROYAL INSTITUTION.

9 p.m. Evening Discourse. "Crystalisation," by Prof. G. D. LIVEING, F.R.S.

SATURDAY, May 16th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture. "The Artificial Production of Cold," by H. GRAHAM-HARRIS, M. Inst. C.E.

WEDNESDAY, May 20th.

ROYAL METEOROLOGICAL SOCIETY.

7 p.m. Ordinary Meeting. Papers to be read: (1) "On the Vertical Circulation of the Atmosphere in relation to the Formation of Storms," by WILLIAM H. DINES, B.A. (2) "On Brocken Spectres in a London Fog," by A. W. CLAYDEN, M.A. (3) "An Account of the 'Leste,' or Hot Wind of Madeira," by H. COUPLAND TAYLOR, M.D. Mr. SHELFORD BIDWELL, F.R.S., will also exhibit an experiment showing the Effect of an Electrical Discharge upon the Condensation of Steam.

THURSDAY, May 21st.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting.

CHEMICAL SOCIETY.

8 p.m. Ordinary Meeting.

FRIDAY, May 22nd.

ROYAL INSTITUTION.

9 p.m. Evening Discourse. "The Molecular Process in Magnetic Induction." By Prof. J. A. EWING, F.R.S.

SATURDAY, May 23rd.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Artificial Production of Cold." By H. GRAHAM-HARRIS, M. Inst. C.E.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

Electrical Observations on the Hoher Sonnblick.—From the results of a series of experiments and of observations on the Hoher Sonnblick at a height of 10,168ft. above the sea-level, Profs. Elster and Geitel draw the following conclusions in the *Wiener Berichte*. (1.) The intensity of the most refrangible rays of the sun's spectrum, as measured by its discharging action on negatively electrified surfaces of amalgamated zinc, increases with the height above level ground, in such a manner that at a height of 10,168ft. it is *twice* as great as on ordinary level ground. (2.) Notwithstanding this increase, no new actinometrically active substances were discovered. (3.) Waterfalls can produce negative falls of potential in a valley, and even to considerable heights, 1,600ft. (4.) Before the outburst of storms observed on the 16th, 18th, and 20th July, 1890, the positive fall of potential, within the cloud which sent only a small quantity of rain, sank slowly down to the value zero, at which it then remained for a long time, perhaps two to three hours, until the electrical process in the cloud definitely came to an end. (5.) In storm-clouds the atmospheric electricity usually changes its sign after a discharge of lightning, as with storms in the plain. (6.) St. Elmo's fire was found to constantly accompany storms; it was not found that *negative* St. Elmo's fire was more infrequent than *positive*. (7.) The observation that negative St. Elmo's fire follows bluish lightning, and positive, reddish lightning, was frequently confirmed. The direction, then, of the electrical current which traverses the atmosphere in the form of lightning appears to have an influence on the colour of lightning.

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THE UNIVERSITY OF LONDON AND ITS DEGREES.

The great interest which has been aroused in educational and medical circles in connection with the proposed reconstruction of the University of London only indirectly concerns most of our readers. It is evidently recognised by the authorities of this institution that it falls lamentably behind an ideal university, and a very vigorous attempt has been made to extend its usefulness. The older and larger universities have a constitution which cannot be easily defined in a few words. A large number of the younger members of the Universities of Oxford and Cambridge join, go through their course, and leave, without acquiring any clear idea as to what their universities really are. They are often looked upon by them as a collection of colleges united together under an organising governing body. Since both the colleges and the university provide lectures, and since both hold sundry examinations, it is not uncommon to find some doubt existing as to whether the college or the university grant degrees. The old idea of a university was "a school where all arts and faculties are taught." Mr. BOMPAS observed at the stormy meeting of convocation on Tuesday that "the University of London had discharged the function of granting a degree which was real evidence of knowledge," and he thus apparently summed up its whole purpose,

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The main object of the proposed new Charter was to raise the University of London from its somewhat insignificant position by making it a teaching University. To do this, something more than an examination hall is required, but there has been no suggestion of new lecture rooms and laboratories. Lord Justice FRY, writing to *The Times*, pleaded that the scheme would bring together the great educational institutions of the metropolis; it would give to University College and to King's College a place on the councils of the University, and would "take account of their educational work in the granting of the Arts degrees. It would also offer a place to the provincial colleges." Why the admirable institutions founded by the City and Guilds of London have not been alluded to in the discussions; where the line was to be drawn in defining the proposed agglomerate of schools; whether Morley College and the excellent Birkbeck Institute and the Regent Street Polytechnic were to be embraced, we have not yet heard; but it does not matter much, as the decision of the Convocation was negative, and, as Lord Justice FRY intimated, the matter is at an end, and the reluctance of the two first-named colleges to participate in the scheme need not be dwelt upon.

The University of London is to be considered, then, as a mere degree-granting body, and the question arises, What is the value of its degrees to education generally, and to the individual recipients? The speaker whom we have already quoted thinks that the University of London has done much to raise the standards of the older universities, and alluded to the worth of the London M.A. degree. The peculiarity of the London degrees is, that the higher ones are of considerably more importance than the corresponding degree at Oxford or Cambridge; while to the lower ones is to be attributed nearly all the mischievous cramming, crammers, and cram-books that have so degraded modern science. It is a well known and an obvious defect in the degrees of Oxford and Cambridge that a B.A. is given alike to one who has just scraped through a pass examination and to the most brilliant of the first class in the honour list; and, after the lapse of three years and the payment of a fee, the M.A. is conferred on each. The latter degree is always proceeded to by those who devote themselves to clerical or educational work, but is not unfrequently neglected by those who are engaged in other professions. There is nothing which corresponds with the London M.A. or the D.Sc. The latter means something more than first-class honours in the Natural Science Tripos of Cambridge, and is a very noteworthy distinction. To the B.Sc., on the other hand, we have a very great aversion, and we are continually reminded of it by the steady stream of text-books which are written to "meet its requirements." The object of the University of London is to examine those who have studied the various subjects by private reading or otherwise. Anyone who has educated himself is invited to come to the testing machine, to drop his guineas in the slot, and to try his strength. The examinee may thus estimate the quantity and quality of the knowledge which he has acquired, and if he receives a degree he has something to show by way of evidence. But no sooner was this system in thorough working order, than a trade was created in the manufacture of students and of books for their use, and anyone of decent intelligence is invited to pay £2. 17s. 6d., or some such amount, in return for which he will be crammed for the matriculation, and, if he fail, the process will be repeated till he passes, or is sick of it. And this is called education. The B.Sc. is an admirable test for the private student whose reading might be most usefully guided by a well prepared syllabus, but this end has been well nigh lost sight of; it has a certain small but defined commercial value in the educational profession as a hall-mark, it affords a livelihood to a number of crammers who encourage the system without attempting to provide any real education, and who bring a permanent discredit on science by the production of the books to which we have alluded.

It is held by some persons that it was a pity that an agitation was raised at Cambridge for the admission of women to the existing examinations, the whole system being established on a wrong basis, and that if they had held aloof and had regarded higher education as a means of making new knowledge, instead of producing examination-passing students, the present system which culminates in examinations might have been revolutionized. There are a few cases in which wholesale scientific teaching is admissible, as, for example, the passing of medical students through an elementary course of physics. At Cambridge such work is done in a special building set apart, with a few demonstrators, for the purpose as it would interfere with the work done at the Cavendish Laboratory.

The University of London, if supplemented by a teaching department, will not make a University in the full sense of the word. No University extensions or *olla podrida* of colleges or "Lord HERSCHELL'S idea of an Imperial degree-granting University for the Empire, with its system of London and provincial colleges," will contribute to the advancement of science or to the benefit of individuals. A very intelligible argument against the establishment of a teaching department is that at present all comers are at an equal advantage, but if the teaching scheme were adopted, those who made use of it would be better able to meet the examiners than the private student or one who might come from some unattached institution. The work that is being done by the numerous Technical Colleges is as valuable as it is varied, both in subject matter and in general character. The desideratum of to-day in London, as far as scientific education is concerned, is the thorough equipment of existing institutions with first-rate laboratories. The £50,000 apiece for which King's College and University College appealed a few months ago would do more good than any new Charter. Scientific education needs expensive plant, and the students' fees cannot defray the current expenses. It is to be regretted that a number of students attend the lectures in physics and chemistry, for which but a small payment is asked, who cannot afford to attend the laboratories and engage in practical work.

The cramming establishments have to provide laboratories, and it is probable that the cast-iron limitations of their teaching has less harmful influence even in the department of chemistry called "test-tubing" than in the book work. First-rate laboratories for the students and for the professors can only be provided by endowment, and the same source must provide for the teaching staff. Charters will not attract good men; these have a definite market value, but the high education which they provide has none. Since London colleges must be self contained, the benefits of the proposed amalgamation are not at all clear. The system of inter-collegiate lectures, which answers admirably at the older universities, cannot be carried out in the metropolis. A student cannot take his mechanics from Prof. PERRY, his chemistry from Prof. ARMSTRONG, his physics from Prof. CAREY-FOSTER, and drop in for his mathematics from Prof. HUDSON. The examinations held at the existing institutions receive very careful attention, and are amply sufficient for satisfying the students as to the proficiency to which they have attained. The University of London would do well to continue, as heretofore, to play the part of the Sphinx, and to propound questions to all who may care to present themselves.

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ELECTRIC AND MAGNETIC THEORIES.

BY SILVANUS P. THOMPSON, D.SC.

§ 1. The proposition to which I invite the attention of Mr. J. T. Sprague is as follows:—

In an electric circuit, the energy which is transferred from the source to the work is so transferred by the operation of the medium surrounding the circuit, the energy passing laterally out of the circuit at the place called the source into the surrounding medium, and passing back laterally into the circuit at the place where the work is done; and the said energy is not conveyed longitudinally along the substance of the copper (or other) wire or conductor, from the source to the work, by an end thrust, as in the case of the transmission of power hydraulically along a pipe full of water.

I trust that all doubt as to the terms of this proposition are already settled by the preliminary propositions of p. 464, as agreed to be amended, on p. 495.

§ 2. The line along which I propose to advance is as follows:—I propose to show, firstly, that there are certain cases in which beyond contest the energy is transferred from the source to the work across the medium. I shall show this first in some cases where there is no metallic or other conductor which can possibly effect a longitudinal transfer, and in which, therefore, the transfer is lateral. I shall then show this in a case or cases in which, though there is present a metallic conductor along which a longitudinal transfer by conduction might occur if that method of transfer of energy were possible, part, at least, of the energy is transferred laterally by the medium. After the discussion of some further cases, and reserving some others for a future occasion, I shall then put to Mr. Sprague the query whether he has evidence of any case in which there is transference of energy that cannot be accounted for by the hypothesis of a lateral transfer through the medium. In short, my argument will be this: since, in those cases in which the hypothesis of lateral transfer cannot in the present state of science be directly demonstrated, there is no evidence to show that the transfer takes place in any other way; then, in the absence of such evidence, one is logically driven to the conclusion that in all cases the mode of transfer is the same as in those cases in which a direct demonstration is possible.

I state this line of argument at the outset, because I wish it to be understood from the beginning what use is intended to be made of the cases that first put forward; for it may be frankly admitted that down to the present moment there are some cases for which I think no direct mode of proof has yet been devised.

§ 3. Incidentally, I now make a remark that is, I believe, of utmost importance to everyone who wishes to enter into the real marrow of this question. We have lived all our lives in a dielectric—the air. The fact that we have grown up in such a medium, and have made our electrical experiments in it, and have acquired our electrical knowledge while living in it, cannot but have an immense effect in moulding and limiting all our conceptions of electric action. Had the atmosphere around us been a good conductor—such as quicksilver, for example—our knowledge of electricity would have been gained in quite a different order of discoveries. Our fundamental ideas, and the language with which we clothed them, would have been quite different from what they are. Living in a dielectric medium, the problem of transmitting energy electrically from one place, A, to another place, B, necessitated that we should construct a metallic conductor from A to B, and our thoughts became concentrated on the *conductor*, which, in our ignorance, we conceived as carrying an invisible current of a supposed fluid, though no mortal man has yet been able to say in which direction the alleged current flowed. Had we, however, lived immersed in a conductive medium, such as quicksilver, the problem presented to us would have taken an entirely different aspect. We should have found metallic wires to be not of the slightest help; eventually it would have been found that a tubular septum of some such dielectric material as gutta-percha would serve the purpose of enabling energy to be transferred from one place to another. We should have laid a tube of gutta-percha through the conducting ocean of quicksilver, like an Atlantic cable. It probably would never occur to us, or only dimly, that anything was carried by the quicksilver either inside or outside the tube; we should have regarded the dielectric tube as the precious all-important instrument of communication, and should have considered it as the carrier of the impulses, by whatever name we called them.

It is to this unfamiliar standpoint that we have now, with pains and trouble occasioned by our necessarily one-sided training, to bring ourselves round. When we contemplate the modern theory as to the propagation of electric actions we have to try to cut ourselves adrift from the point of view of persons who happen to have been born and to have lived and moved immersed in a dielectric, and whose whole thought is tinged with ideas bred of that circumstance. Many of the difficulties which arise to the electrical student in considering the modern theories, some, indeed, of those raised by Mr. Sprague in his articles, are simply the natural inevitable result of this environment of thought.

§ 4. I proceed at once to those cases in which it can be directly demonstrated that the energy which impels the current travels across the dielectric medium. Fig. 1 represents two circuits in which there have been inserted two coils, A and B, having such relative positions as to possess mutual induction. In the circuit of A is inserted a suitable battery or other source, S, of current, and a key, K. In the circuit of B is inserted a galvanometer, G. When K is depressed a current is established in A. Were B absent, or not closed on itself, the current in A will take a certain time to rise to its full strength. When B is present, the variable period of the current in A is of shorter duration,

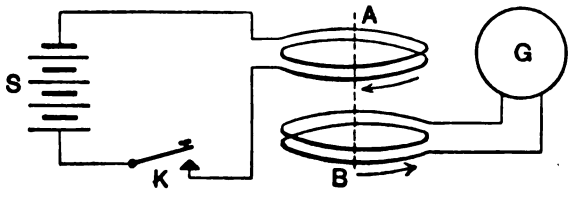

FIG. 1

more energy being drawn from the battery S. But during this period, while the current in A has been rising in strength, an induced current will be observed to circulate in B; and will manifest itself by moving the needle of the galvanometer, and by slightly heating the wire of the B circuit. This means that some work has been done in B; at the expense of the actions in S which furnished the energy to the system. How, then, did the energy pass from S to the B circuit? Evidently, by the intermediate agency of the coil A, from which the energy has crossed the space separating it from the B circuit. This energy has been transmitted by the medium which lies between, and has obviously entered the coils of the B circuit in directions which are transverse to the flow of the induction current. It was proved many years ago by Sir William Thomson that, in such an operation as this, the energy drawn from the source is just double that which is manifested as heat in the B circuit. Of the whole energy thus drawn from the source (over and above that which is accounted for in the A circuit) one-half only is manifested in the transient current in the B circuit; the other half is employed in bringing the medium between A and B into the peculiar state of stress which subsists and increases the potential energy of the system while it lasts. On breaking circuit at K this energy also disappears from the medium; and a second induction current in the B circuit (this time in the opposite direction to the former induction current) announces that this other half of the energy has now been transferred into the circuit B and spent therein. In all these there is nothing which would in the remotest manner suggest an end thrust in the B circuit. The energy has entered laterally from the medium into the conductor, and done its work.

That the medium is *the* agent in this operation there can be no manner of doubt; for the amount of the action is found to depend in the most direct and striking way upon the medium

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itself. Let the conductive circuit, A and B, be unchanged in every respect, but let a bundle of iron wires be inserted as a core, in place of air, where the dotted line lies from A to B. At once there is an enormous augmentation of the actions. Ten, twenty, or even fifty times as much energy as before is now transferred at each opening and closing of the key from the circuit A to the circuit B. It is obvious that the energy path is through the medium, and is affected by the choice of materials to be used as a medium.

§ 5. Now let us consider a second case. Let A (Fig. 2) be a Hertz oscillator, consisting of two metal rods terminated by polished balls, and ending in flat metal sheets. They are connected to the discharging apparatus of an inductorium which causes occasional sparks to pass across between the balls. Every spark (as can be demonstrated in various ways) consists of a series of rapid discharges oscillating across the gap between the balls.

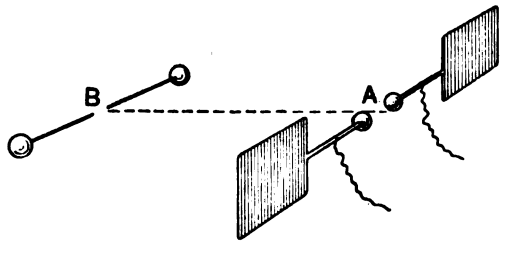


FIG. 2.

Opposite the spark gap of A is placed a Hertz explorer, B, consisting of two metal rods of suitable length, with a minute gap between them. As every spark flashes across at A, a corresponding spark is seen at B, provided the exploring device is properly adjusted and held parallel to the rods of the oscillator. It is obvious that in this case some of the energy imparted to the oscillator, A, has crossed the intervening medium to B, and here manifests itself in light and heat. The transfer is again lateral, by means of the medium, not longitudinal, or by an end thrust along a wire.

§ 6. Let us consider a third case, namely, one of Prof. Elihu Thomson's experiments with alternating currents. Let an alternating current be introduced into a coil, A, surrounding a bundle of iron wires as a core. Opposite it let a sheet of copper, B, be placed, as in Fig. 3. If B is held still it is found

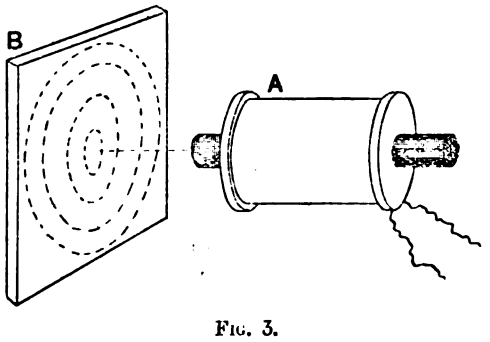


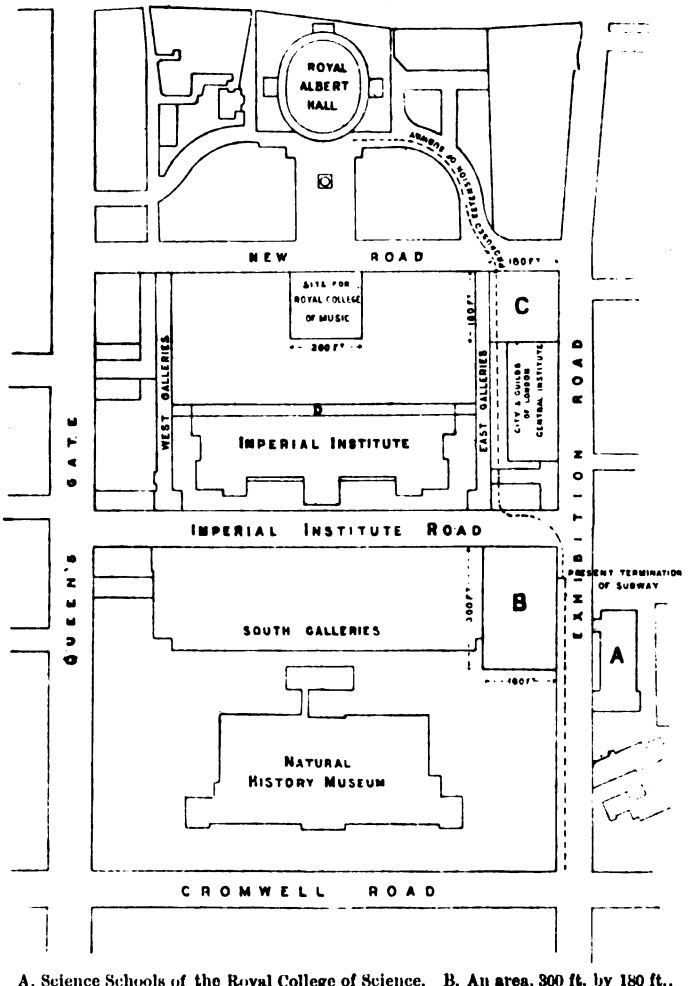
FIG. 3.

to heat; and by proper contrivances it is easy to show that alternating currents are being set up in it, in eddies which centre, approximately, around the axial line between A and B. These currents may be of great strength, as evidenced by the rapid and considerable heating, and by the powerful mechanical repulsion which ensues between B and A. Again, this is a case in which it is clear that the energy which has traversed the apparatus from A to B has crossed the medium separating the two, and has entered the copper sheet by paths the general direction of which is at right angles to the same, and therefore laterally with respect to the induced currents. There is nothing to suggest an end-thrust as propelling the currents in question.

(To be continued.)

SCIENCE versus ART AT SOUTH KENSINGTON.

The accompanying plan will explain to our readers the details of the very important discussion which has arisen as to the disposal by the Government of land for a new picture gallery. The area B has been selected by Mr. Tate as the site for the Gallery of British Art which he so liberally offers to build. Its dimensions are said to be much too large for an expenditure of £80,000, which sum it has been decided shall not be increased by the addition of public money.



A, Science Schools of the Royal College of Science. B, An area, 300 ft. by 180 ft., at present occupied by a Physical Laboratory and two small Observatories of Mr. Lockyer. C, a site, 150 ft. by 180 ft., partly occupied by the School of Art Needlework. D, Corridors now in course of erection.

The area C would have immediate connection with the east galleries, and these are pronounced by the leading artists to be the best lighted and best proportioned in England. The Science collection is at present scattered all over the place, as far as the west galleries.

NOTE ON A MODIFICATION OF THE METHOD OF CONNECTING UP TELEPHONIC APPARATUS.*

BY E. MASSIN.

The London-Paris telephone line was completed on Saturday, March 14th, by the laying of the submarine cable from Sangatte to St. Margaret's Bay. The following Tuesday the first experiment showed that success had crowned the enterprise, and that communication could be easily effected between the central offices. All the instruments adopted in France for subterranean lines enabled conversation to be carried on more or less favourably. With the Gower-Bell, the Post Office instrument, communications were also exchanged without difficulty. Amongst the apparatus tried, the one which seemed to me to be the best, from the point of view of volume and clearness of sound, was the Roulez instrument.

In the Roulez instrument, the vibrating diaphragm is a carbon plate 10cms. in diameter. On this diaphragm is screwed a block of carbon 7cms. long, its face of contact being covered with a sheet of

* *Annales Télégraphiques*, Vol. XVIII. Third Series.

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Bristol-board (Fig. 1), which acts as an insulator. The plate and block, insulated from one another by the Bristol-board, constitute the two poles of the microphone. The current gets from one pole to the other across fragments of incandescent lamp filaments arranged in three holes hollowed out of the carbon block and insulating sheet.

I have stated that conversation was easy between the General Post Office and the Paris central office; but as soon as we added to the main line the high resistance gutta-percha covered cables which connect the central to the secondary offices, the state of affairs was altered, the voice was muffled, and while conversation was still practicable between two persons accustomed to converse by telephone, it was not, generally speaking, possible. If we took the most complex case, and tried to speak from a London subscriber's house to one at Paris, the voice was clear enough, but the volume of sound was insufficient for telephonic working.

With the existing urban lines only one apparatus was able to give the desired quality and volume of sound, namely, the Roulez microphone, arranged as in Fig. 2, where the receivers and the secondary of the induction coil are placed in parallel across the line. A special key closes the telephonic circuit, either of the receivers or of the secondary, but does not allow the two to be simultaneously to line. Instead of this arrangement, which was carried out in the apparatus employed at the Paris Observatory and the Treasury, one can keep both receivers and secondary in series and constantly in circuit, as is usually done, and content oneself by neutralising one or the other of the two parts by short circuiting them.

The theoretical advantages of the above modification of the usual arrangement are as follows: (1) The receivers do not spoil the transmission and the presence of the transmitter does not weaken the sound received; (2) the operator in the case of long lines does not have his ears deafened from the beginning by the currents

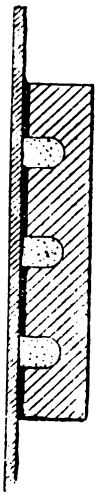

Fig. 1.

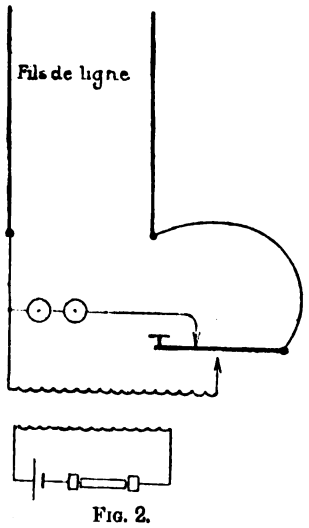

Fig. 2.

generated by his own transmitter and traversing his receivers; (3) it is possible to increase the currents in the primary without fear of having currents in the microphone at the far end to cause troublesome crackling in the receivers at that end.

In the experiments between the Paris Observatory and the Treasury, a battery of 10 Lalande cells arranged in series was used. With a *non-modified* Roulez this battery produced deafening cracklings in the receivers, and conversation was impossible. But with the modified instrument conversation was perfect, the voice arrived loud and clear, and one could even keep the receivers at some little distance from the ears and still perfectly understand what was being said.

This modification, therefore, possesses undeniable practical advantages. Applied to the Roulez instrument it increased the intensity of the sounds received at the Observatory and at the Treasury by 4 to 1, thus rendering conversation possible between a London branch office and a Paris subscriber, to the exclusion of all other instruments tested. But the arrangement possesses two drawbacks, which are—firstly, the manipulation of the key; and, secondly, the impossibility of interrupting one's correspondent, who cannot be made to hear so long as he is transmitting. The key is fitted in the handle of one of the receivers, and is manipulated with the thumb of the right hand; the button is pressed when transmitting, and freed when listening. This very simple manœuvre is easily learnt, and after two or three minutes' conversation the button is automatically moved without thinking. The impossibility of cutting into the conversation seems to me the only real disadvantage of the arrangement described, and we may ask whether this defect is not greatly compensated for by the increased range given to the telephone, and by the possibility of establishing communication between a Paris subscriber and a London branch office.

ON SOME EFFECTS OF ALTERNATING-CURRENT FLOW IN CIRCUITS HAVING CAPACITY AND SELF-INDUCTION.*

BY DR. J. A. FLEMING.

(Continued from page 202.)

9. These considerations point out that, in applying either transformers or alternators to circuits which have capacity, we must have regard to the fact that, for certain critical values of the inductance and the capacity for given frequencies, there may be a very considerable increase fn the potential difference of the two sides of the condenser over and above that of the poles of the alternator or transformer when no condenser is present. Such effects have been noticed in practice of late. It has been frequently found that if a transformer which gives on its open secondary circuit a certain potential difference is applied to test the insulation of a length of concentric cable by connecting its terminals to the two conductors, the far ends of the cable being insulated, under some circumstances an increased potential difference is observed between the free ends of the cable over and above that at the terminals of the transformer when the cable is not connected to it. When transformers have been employed to test the insulation of armatures of high-pressure alternators, it has been noticed that under some circumstances large snapping sparks will jump off over air distances which could not possibly permit discharges at the actual potential difference of the secondary terminals of the transformer so used when unconnected with any such body having capacity.

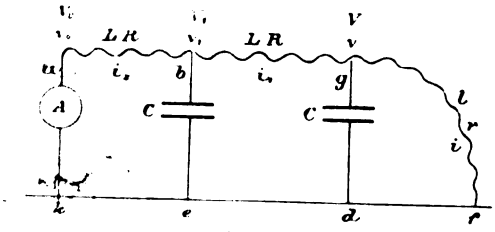

Fig. 7.

In employing an alternator or transformer to test insulation between two opposed conductors, or in any way in which the opposed terminals gain capacity, it is necessary to be on the watch for this possible rise of pressure, and not to infer, because a transformer gives, say, 2,000 volts on open circuit between its poles when measured with an electrostatic voltmeter, that therefore this is the measure of the pressure which is being applied to a dielectric which forms the insulator of a condenser joined in across the poles of that transformer.

I am not at all sure that, under some circumstances, errors may not be committed in the mere use of an electrostatic voltmeter to measure potential difference between the poles of an alternator or a transformer, if that voltmeter happens to possess a certain capacity in relation to the inductance of the circuit in which it is joined in parallel.

10. It is easy to treat in the foregoing manner another case slightly more complicated.

Let the inductive line $a\,b\,g\,f$ (Fig. 7) be divided into three sections, $a\,b$ and $b\,g$ having each resistance R and inductance L, and the section $g\,f$ having r and l for similar quantities. Let condensers of capacity C be inserted in b and g. If v and v_1 are the potentials at any instant of the condenser terminals, and i, i_1, and i_2 the instantaneous currents in the sections of the line, and I, I_1, and I_2 the maximum values of these periodic currents, it is not difficult to show, with our former notation, that

$$v_1 = \frac{I}{C\,p}\Big((B\,a+A\,b)\sin p\,t+(B\,b-A\,a+1)\cos p\,t\Big) \quad . \quad (21),$$

but

$$i_2 = i_1 + C\frac{d\,v_1}{d\,t},$$

and

$$i_1 = I\,(a\sin p\,t + b\cos p\,t) \quad . \quad . \quad . \quad . \quad . \quad (22)$$

by (12). Hence we have,

$$i_2 = I\{(A\,a-B\,b+a-1)\sin p\,t+(B\,a+A\,b+b)\cos p\,t\} \quad . \quad (23),$$

from which we deduce that the ratio of the maximum currents, I_2 and I_1, in the first and second sections of the line, is given by the equation,

$$I_2 = I\sqrt{(A+1^2+B^2)\,(a^2+b^2)+a\,b\,A-B-2\,a\,A+1+2\,B\,b+1} \quad (24),$$

and in like manner the ratio of the maximum values of the potentials V_0 and V_1 can be obtained.

* Paper read May 7, 1891, before the Institution of Electrical Engineers.

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It is possible also to show that for certain critical values of L, C, and R, the potentials V_0, V_1, and V, at the terminals of the alternator and at those of the condensers, progressively increase, as well as the currents in the sections of the line. Cases of this kind, beyond a single condenser, are best treated as Mr. Blakesley has done—by geometrical methods.

11. In the limited case of a condenser charged by an alternating electromotive force through an inductive circuit, we may arrive at a direct analytical solution of the relation between the coefficients of induction and capacity of the system and the mean square of the charging current, and of the potential difference at the poles of the condenser or at those of the alternator, as follows:—As before, let V_0 and v_0 stand for the maximum and instantaneous values of the potential difference at the poles of the alternator; let V_1 and v_1 be the same quantities at the terminals of the condenser; and let I and i be the same for the current flowing into the condenser having a capacity C, whilst the line connecting the condenser with the alternator has an inductance L and a resistance R. We have, then, by fundamental equations, the following relations:—

$$L\frac{d\,i}{d\,t}+R\,i=v_0-v_1 \quad . \quad . \quad . \quad . \quad . \quad (25),$$

$$i=C\frac{d\,v_1}{d\,t} \quad . \quad . \quad . \quad . \quad . \quad . \quad (26).$$

Also, let $v_0=V_0 \sin p\,t$, and hence

$$i=I \sin (p\,t+\theta),$$

where θ is the angle of lag of current behind the impressed electromotive force.

Eliminating v_1 from the above equations we have,

$$L\frac{d^2\,i}{d\,t^2}+R\frac{d\,i}{d\,t}+\frac{i}{C}=p\,V_0 \cos.\ p\,t \quad . \quad . \quad . \quad (27),$$

or since, for simple periodic currents, $-p^2=\frac{d^2}{d\,t^2}$, we have,

$$\frac{d\,i}{d\,t}+\frac{1-C\,L\,p^2}{C\,R}\,i=\frac{p\,V_0}{R}\cos.\ p\,t \quad . \quad . \quad . \quad (28).$$

This equation is of the form,

$$\frac{d\,i}{d\,t}+Pi=Q\cos p\,t,$$

the solution of which is known to be

$$i=\frac{Q\,P}{P^2+p^2}\cos p\,t+\frac{Q\,p}{P^2+p^2}\sin p\,t;$$

and an easy transformation gives us, therefore, the solution for the particular case in hand as

$$i=\frac{(1-C\,L\,p^2)\cos p\,t+C\,R\,p\sin p\,t}{(1-C\,L\,p^2)^2+C^2\,R^2\,p^2}\,C\,p\,V_0 \quad . \quad . \quad (29).$$

This can be written also,

$$i=\frac{C\,p\,V_0}{\sqrt{1-C\,L\,p^2)^2+C^2\,R^2\,p^2}}\sin(p\,t-\phi) \quad . \quad . \quad (30),$$

and the maximum value of i, viz., I, is, therefore,

$$I=\frac{C\,p}{\sqrt{(1-C\,L\,p^2)^2+C^2\,R^2\,p^2}}\,V_0. \quad . \quad . \quad . \quad (31).$$

This gives us the mean square, or dynamometer, value of the current I flowing into the condenser in terms of the mean square value of the potential difference of the poles of the alternator and the coefficients C, L, R, and p. If $C\,L\,p^2=1$, then the value of I reduces to $\frac{V_0}{R}$; in other words, for this particular value of the relation between the inductance and the capacity, the whole system of inductive charging line and condenser acts as if it were a non-inductive conductor of resistance R.

We see also that this equation (31) can be made use of to determine L from observed values of I_1, V_0, C, R, and p, or else C when L is known. The value of the mean inductance of the line is given by the equation,

$$L=\left(\frac{1}{C\,p^2}-\frac{1}{p}\sqrt{\frac{V_0^2}{I^2}-R^2}\right) \quad . \quad . \quad . \quad . \quad (32),$$

which gives L in terms of observable quantities.

The current at any instant flowing across the dielectric of the cable may be spoken of as the *condenser current*. It is always in magnitude equal to the product of the capacity of the condenser and the time rate of change of the mean potential difference, v_1, of its surfaces. It follows that, in the case of simple periodic currents, the square root of the mean square of this current, I, which is what we measure with a dynamometer, is equal to the product of the square root of the mean square of the condenser plate potential difference V_1, and the quantity $C\,p$, where C is the capacity of the condenser, and p, as usual, is $2\,\pi$ times the frequency, or $I=C\,p\,V_1$. This follows at once from equations (19) and (31). The value of the potential difference at the terminals of the condenser, as measured, say, by an electrostatic voltmeter, is therefore determined by the magnitude of the condenser current flowing into it, as measured by a dynamometer when the frequency of the current is known.

12. The writer witnessed some experiments made in the Standardising Laboratory by Major Cardew, in which the above measurements were carried out. A condenser of ·5 microfarad was joined across the poles of an alternator, a Thomson deciampere balance was put in the charging circuit, and a Thomson multicellular electrostatic voltmeter across the terminals of the condenser. The readings of the voltmeter, V_1, and of the ampere balance, I, were taken simultaneously, with the following results:—

Frequency of current, n.	Volts across condenser poles, V_1.	Charging current in amperes, I.	
		Observed.	Calculated.
103	360	·132	·116
103	396	·145	·128
103	493	·175	·160
103	583	·200	·189
90	481	·150	·136
90	598	·187	·170

For the frequency $n = 103$, $p = 2\,\pi\,n = 647$, and for $n = 90$, $p = 565$.

Hence, since the condenser capacity, C, = ·5 microfarad = 5×10^{-7} farads, we have as the values of $C\,p$ for the respective speeds $3{,}235 \times 10^{-7}$ and $2{,}825 \times 10^{-7}$, and the values of the condenser current are calculated from the relation $I = C\,p\,V_1$.

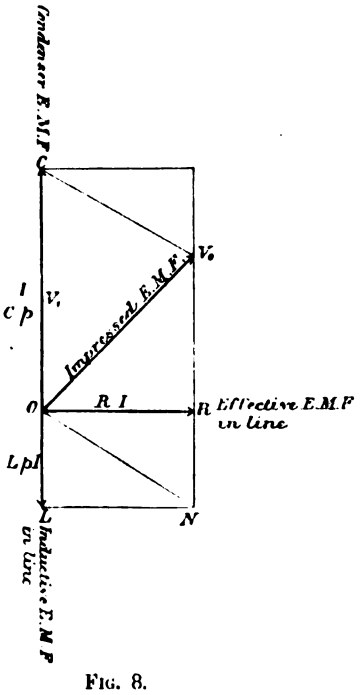

FIG. 8.

The calculated values of the currents are all lower than the observed, and in about the same ratio, viz., about 10 per cent.; but the speeds of the alternator, and therefore the current-frequencies, were not known with a degree of accuracy sufficient to enable it to be determined how far the agreement of observation with theory is complete.

13. The relations between the capacity and self-induction necessary to bring about an increase of pressure at the condenser terminals when an alternator charges a condenser are well displayed by the use of a clock-diagram of electromotive forces. Such diagrams have been given by Mr. Kapp in some recent papers, and the particular one here given is practically the same as one given to me by Major Cardew, who has also examined this particular problem. The following mode of regarding it will be found to be an easy one. Construct a clock-diagram of electromotive forces (see Fig. 8) for the simple case of a condenser charged through an inductive line by a constant harmonic impressed electromotive force. Lines drawn radially from a point, O, in Fig. 8, represent the maximum values of various electromotive forces. Let O V_0 be the maximum value of the impressed E.M.F. at the dynamo terminals, and O C that at the condenser terminals; I the maximum current in the line. Take any line O R to represent the effective

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E.M.F. in the line, and therefore equal to the product R I, where I is the current charging the condenser, and R is the resistance of the line. From R draw R L at right angles to O R, and let R L be set off equal to $L\,p\,I$; L being the inductance of the line, and p being, as usual, $2\,\pi$ times the frequency of the current. Note that when a quantity varies harmonically the product of p and its maximum value gives us the maximum value of its time rate of change, or time differential, whilst the quotient of its maximum value by p gives us the maximum value of its time integral. Accordingly, O L, which is made equal to $L\,p\,I$, represents the counter electromotive force of self-induction, or back E.M.F., in the line as far as is due to its own inductance, and is in quadrature with R I as regards phase. Hence the resultant of these two is O N. Next set off O C at right angles to O R, and in advance of it, and make O C equal to $\frac{I}{C\,p}$, that is, to the maximum value of the quotient of the time integral of the charging current by the capacity of the condenser. This gives us the counter electromotive force of the condenser, or the E.M.F. at the terminals of the condenser, V_1. We have then to take the resultant of this last and O N, which gives us $O\,V_0$, and this last resultant is the impressed electromotive force at the dynamo terminals.

It is necessary to bear in mind that the counter electromotive force, O C, at the terminals of the condenser is in quadrature with the current flowing into it, and in advance of it in phase. The diagram shows us at once that the pressure, $V_0 = O\,V_0$, at the terminals of the dynamo may be less than, equal to, or greater than the pressure, $V_1 = O\,C$, at the terminals of the condenser; and that this is determined by whether the length of the line, $O\,V_0 = \sqrt{O\,R^2 + V_0\,R^2}$, is greater or less than O C. We see that $V_0\,R = O\,C - O\,L = \frac{I}{C\,p} - L\,p\,I$, and hence that O V_0 is equal

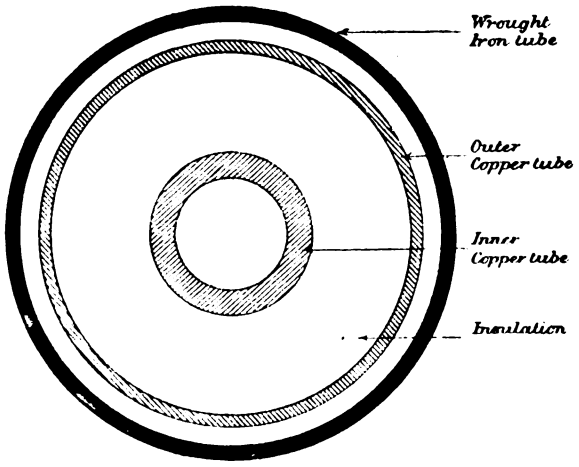

Fig. 9.—Section of Ferranti Trunk Main—Full Size.

to the square root of $\left\{ R^2 + \left(\frac{1}{C\,p} - L\,p\right)^2 \right\} I^2$. Hence the maximum value of the charging current, I, is given by the value of

$$\frac{C\,p\,V_0}{\sqrt{R^2\,C^2\,p^2 + (1 - C\,L\,p^2)^2}}$$

Also we have the same quantity given by the relation $I = C\,p\,V_1$; hence the ratio of V_0 to V_1 is given by the value of the quantity $\sqrt{(1 - C\,L\,p^2)^2 + C^2\,R^2\,p^2}$, as we have already seen analytically. The clock-diagram has the advantage that it shows us at once the various lags, and gives explicitly to the eye a proof that a gradual increase in the value of the inductance, L, from zero upwards is accompanied by a progressive decrease in the value of the terminal pressure, V_0, at the dynamo, as compared with the terminal pressure, V_1, at the condenser.

14. In the next place, I wish to place before you an analysis of some experiments which have been made on great lengths of the Ferranti trunk mains between London and Deptford, and which illustrate these principles in a remarkable manner. We are all aware that these cables are concentric cables, and that they possess, accordingly, very measureable electrostatic capacity. The following are the data of the dimensions of these cables, kindly given to me by Mr. Ferranti. The inner conductor, or inner member, is a copper tube (see Fig. 9) of which the inside diameter of cross section will be called D_1, and radius R_1, and the outside diameter D_2, and radius R_2. The outer conductor, or member, is a copper tube of which the inside diameter will be called D_3, and radius R_3, and its outside diameter D_4, and radius R_4. The insulation between the inner and outer members is compressed brown paper and black wax. The values of the diameters and radii of cross section of these tubes are as follows (see Fig. 7):—

$D_1 = \frac{9}{16}$ of an inch = ·5625 in.
$D_2 = \frac{13}{16}$,, ,, = ·8125 ,,
$D_3 = 1\frac{37}{64}$,, ,, = 1·8437 ,,
$D_4 = 1\frac{15}{16}$,, ,, = 1·9375 ,,

Hence we have—

$R_1 = $ ·281 in. $\quad R_1^2 = $ ·0789
$R_2 = $ ·406 ,, $\quad R_2^2 = $ ·1648
$R_3 = $ ·922 ,, $\quad R_3^2 = $ ·8500
$R_4 = $ ·969 ,, $\quad R_4^2 = $ ·9389
$R_2^2 - R_1^2 = $ ·0850 ,, $\quad R_4^2 - R_3^2 = $ ·0889

Area of cross section of inner member $= \pi\,(R_2^2 - R_1^2) = $ ·2689 sq. in. = $\frac{1}{4}$ sq. in., nearly.

Area of cross section of outer member $= \pi\,(R_4^2 - R_3^2) = $ ·2793 sq. in. = $\frac{1}{4}$ sq. in., nearly.

Also, we have—

$$\frac{R_3}{R_2} = 2{\cdot}270 \qquad \frac{R_2}{R_1} = 1{\cdot}444 \qquad \frac{R_4}{R_3} = 1{\cdot}051,$$

$$\frac{R_1^2}{R_2^2 - R_1^2} = {\cdot}9185, \qquad \frac{R_4^2}{R_4^2 - R_3^2} = 10{\cdot}561,$$

$$\frac{2\,R_1^4}{(R_2^2 - R_1^2)^2} = 1{\cdot}6872, \qquad \frac{2\,R_4^4}{(R_4^2 - R_3^2)^2} = 223{\cdot}068,$$

$$\log_e \frac{R_3}{R_2} = \log_{10} 2{\cdot}27 \times 2{\cdot}3026 = 2{\cdot}3026 \times {\cdot}35603.$$

These quantities are required in the calculation of the inductance of the cable.

If the specific inductive capacity of the dielectric were a definitely known quantity, it would be, of course, easy to calculate from the above figures the capacity of one mile run of the cable by the formula,

$$\text{Capacity in electrostatic units} = \frac{K\,l}{2\,\log_e \frac{R_3}{R_2}},$$

K being the specific inductive capacity, and l the length; and to reduce this to farads by multiplication by $\frac{1}{9 \times 10^{11}}$.

In default of information to enable this to be done, the electrostatic capacity of one length was measured directly by comparison with a standard half a microfarad.

On December 5th, 1890, Mr. Ferranti placed at my disposal two lengths of the trunk mains running from Trafalgar-square to Blackfriars, for the purpose of measuring the capacity. The length of cable used was 2,399 yards, or 1·363 statute miles. The capacity of one of these lengths (No. 3 cable) was found in the usual way (taking the capacity between the inner and outer members) to be ·5 microfarad for the whole length, or at the rate of ·367 microfarad per statute mile. It follows from this that the specific inductive capacity of the material used is about 3·4 (air = 1). Using the other cable (No. 4), the copper resistance was found to be ·324 legal ohms, or ·328 B.A. units per statute mile, reckoning the resistance per mile run of the cable, and including, therefore, both the inner and outer conductor. The insulation resistance between the inner and outer member of the first cable was found to be at the rate of 720 megohms per mile. The instruments used in taking these measurements were a half-microfarad condenser by Dr. Muirhead, and a legal ohm Wheatstone bridge and megohm standard, kindly lent by Messrs. Elliott Bros. for the purpose. The temperature of the ground on that day was near the freezing point, and Nature saved us the trouble of reducing the values to zero centigrade.

The remaining element required is the inductance of the cable per mile. Fortunately, the form of cable which is the best for practical reasons is almost the only case in which the inductance can with no great difficulty be calculated with any required degree of accuracy from the dimensions of the cable. Lord Rayleigh has solved for us the problem of the inductance of a pair of concentric conductors placed co-axially. His formula, as given in his Paper in the *Philosophical Magazine* of May, 1886, p. 385, is as follows, when translated into my nomenclature, and the values of the magnetic permeabilities of the materials all taken as equal to unity:—

$$L = \text{inductance per unit of length} = 2 \log \frac{R_3}{R_2} + \frac{2}{R_2^2 - R_1^2}\left(\frac{R_2^2 - 3\,R_1^2}{4} + \frac{R_1^4}{R_2^2 - R_1^2} \log \frac{R_2}{R_1}\right) + \frac{2}{R_4^2 - R_3^2}\left(\frac{R_3^2 - 3\,R_4^2}{4} + \frac{R_4^4}{R_4^2 - R_3^2} \log \frac{R_4}{R_3}\right).$$

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The logarithms are all Naperian, and the values of R_1, R_2, R_3, and R_4 may be taken in any units, as only their ratios are required.

The values of the chief functions of the radii of the tubes have been given above, and, making the substitutions, we have for the inductance of one centimetre run of the cable the following value:—

$$L = 2 \log 2{\cdot}27 + 1{\cdot}6872 \log 1{\cdot}444 + 223{\cdot}068 \log 1{\cdot}051 - (9185 + 10{\cdot}561).$$

Remembering that the logarithms here are Naperian, and that the logarithms to base 10 must be multiplied by 2·3026 to reduce them to the Naperian base, we have as a final result of the calculation,

$$L = 1{\cdot}7755 \text{ centimetres.}$$

Hence, since one statute mile = 160,931·5 centimetres, the inductance per statute mile of the Ferranti cable is 285,734 centimetres = ·0002857 of a henry, or 285·7 microhenrys.

This result will be accurate to just the extent to which the diametrical measurements of the conductors are accurate.

Collecting our results, we have for one statute mile run of the Ferranti trunk main the following values, as deduced from measurements on the particular lengths employed:—

R = Copper resistance at 0° cent. of lead and return ..... = ·324 legal ohm per mile.

K = Insulation resistance of length measured at rate of ..... = 720 megohms per mile between inner and outer conductor.

C = Electrostatic capacity between inner and outer conductor ..... = ·367 microfarad per mile.

L = Inductance ..... = 285·7 microhenrys per mile.

The formula given above for the inductance per unit of length can be applied to stranded concentric cables with a fair degree of approach to accuracy.

Suppose that we are sending periodic currents having a frequency of 67 through the Ferranti cables, then, if n = frequency = 67, $2\pi n = 421 = p$, and $4\pi^2 n^2 = p^2 = 177{,}241$.

Hence, since R = ·324 ohm, and L = ·000286 henry, we have $\sqrt{R^2 + p^2 L^2} = {\cdot}3455$ ohm for the impedance per mile, and we see that at this frequency the impedance exceeds the resistance by about 7 per cent. of the latter.

From the data thus given other functions of the capacity, C, inductance, L, resistance, R, and impedance, I, per mile can be built up, which will be required presently. These are—

$$P^2 = \frac{C p}{2}\left\{\sqrt{R^2 + p^2 L^2} - p L\right\} = {\cdot}00001738;$$

$$Q^2 = \frac{C p}{2}\left\{\sqrt{R^2 + p^2 L^2} + p L\right\} = {\cdot}00003597.$$

Hence, also,

$$P = {\cdot}004168,\ Q = {\cdot}005997;$$

$$P^2 + Q^2 = {\cdot}00005335,\ \frac{P^2 + Q^2}{I^2} = \frac{447}{10^6};$$

$$(2 P R + 2 Q L p) = {\cdot}004147;$$

$$(2 P L p^2 - 2 Q p R) = -1{\cdot}216.$$

All the quantities refer to one mile run of the cable.

(To be continued.)

SOME RESEARCHES IN ELECTRO-MAGNETIC INDUCTION.*

BY E. B. VIGNOLES.

The subject of electro-magnetic induction is one whose ramifications extend into almost every commercial application of electricity. I need, therefore, little excuse for bringing before you to-night a short account of an investigation into induction phenomena which, even if it traverses somewhat well-trodden ground, presents some novel features of method and application which may perhaps repay your attention.

Before proceeding to describe to you the method used by Mr. Evershed and myself in these investigations, I may perhaps briefly state the circumstances which led to our undertaking the research. When we started our experiments some two years ago, the subject of transformers was being much discussed; and as we, in common with most other people, were rather hazy in our ideas concerning the actions of this convenient but perplexing machine, we determined to investigate these actions from the beginning by determining, *de novo*, the magnetic properties of closed rings of various materials. The method of drawing the actions of a transformer as described in Mr. Evershed's Papers in *The Electrician*, was then in process of conception, and he saw that these curves were the one thing needful. We knew, of course, that Ewing and Hopkinson had already published similar curves, but their Papers are somewhat inaccessible, and their methods seemed to us open to some objections, objections of which I will treat further on.

But before I proceed to further describe the methods used, it may be as well, since the nomenclature of magnetic phenomena is in a somewhat amorphous condition, to describe the sense in which various terms will be used in this Paper.

The first thing that we have strongly set our faces against is the use of the term "induction" in the sense of "induction density." It is as if we had no term for current, and used current in the sense of current density. It simplifies one's nomenclature to call **B** × area "the induction," just as in the case of current; and to call **B** the "induction density," and I shall take the liberty of doing so in this Paper.

I shall not allude to "I," for the good reason that I can form no conception of what it means physically. I fancy it is something to do with the induction density that would have been present in an electric circuit if the iron which is there wasn't there! It seems useless to make such artificial distinctions, and I follow Dr. Hopkinson's distinguished example in treating of nothing but **B**, **H**, and μ.

The remaining point as regards nomenclature is the abuse of the term "lines of force." As expressing the direction in which the induction acts at various points, they have an obvious and valuable use; but these lines do not increase or diminish as the induction becomes greater or less. Whether you have 10^{-10} or 10^{+10} units of induction, the lines of force remain precisely the same. They should be symbols of *direction* and not of *quantity*. The use of the term "lines of force" for units of induction, not only leads to false mental pictures, but it is clumsy. We were, therefore, compelled to invent a new unit for induction, as no one else had done so. This unit was born some two years ago, and was christened the "thom," after our leading electrician. It serves its purpose: you can speak of a "thom" without committing yourself to anything, or thinking of anything in particular.

The Paris Congress has adopted a unit of induction density called the Gauss. It is really an unnecessary unit, as "Thoms per sq. cm." is all that is required; but it is convenient, and we have always used it. It simplifies the numbers on the curves of **B** and **H** to call 1,000 gausses, a "kilo-gauss" in the usual metric manner; and I have done this in my tables and curves, where **H** is in dynes, and **B** in "kilo-gausses."

Having thus explained my use of terms, let us return to the consideration of the action of iron in transformers.

The importance of imitating as closely as possible the action of the magnetising current in a transformer strongly impressed us. We saw that it was necessary, when investigating any induction cycle, to carry the iron through that cycle before every observation, and always to start from one extremity of the cycle.

It may be said that the ordinary method of procedure, by reducing the current from the negative maximum by jumps to O, increasing to the positive maximum in the same way, and then reversing the process, noting at each jump the throw of the ballistic galvanometer, is equally good; but this is not so, for in a transformer you are not stopping anywhere on the force-induction curve, except at the positive and negative maxima. It might happen that the iron behaved differently in the two cases; and we know from Ewing that the induction has a tendency to creep up under the prolonged action of a magnetising force.

Magnetometer methods were out of the question, for iron rods do not behave like closed rings, unless, according to Ewing, their length is about 400 times their diameter. As we wished to experiment on masses of iron, and not on wires, which might, and in fact do, behave very differently, the minimum diameter we could have used would have been half an inch. This makes our rod 18 feet long, which is somewhat alarming.

Hopkinson's method is a very handy and convenient one, but the fact that it introduces other material than the one under test, and that at least two, and generally three, joints are necessary parts of the magnetic circuit, is a great disadvantage. It may be that a very small portion of the magnetising force is spent on the "return" block, but still there is always something; and that something is rendered somewhat indefinite by the hysteresis of the block. This amount may, however, be indefinitely reduced by making the block big enough, but it is not so with the joints. It will always take an appreciable percentage of the magnetising force to push the induction through these joints, and this percentage will vary in every sample of iron tested owing to minute differences in the tightness of the joint. It will be noted that since the bar has to be pulled out suddenly, the joint with the block can never be

*A Paper read before the City and Guilds of London Institute Old Students' Association, May 13, 1891.

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made really very tight A modification of this method using very ght joints, and winding with wo primaries (as in our method) to avoid having to pull out the test bar, might have its advantages; for it would no longer be necessary to wind each sample of iron, which is of course essential in the ring method, and it saves one joint; but turning the bars would entail nearly as much work as winding a ring, and work of a more expensive class, for any boy can wind one of our rings properly, but accurate turning would require more skilled labour. Thin laminæ of iron, as used in transformers and armatures, cannot be tested by this method, which practically puts it out of the question.

The most important experiments performed by means of rings, according to Kirchhoff's method, are those of Bosanquet. He, however, did not, as far as I know, take hysteresis curves, but confined himself to average curves, obtained by means of the reversal method. For testing iron where the amount of coercive force is not required this method is excellent, and many of our curves have been thus obtained.

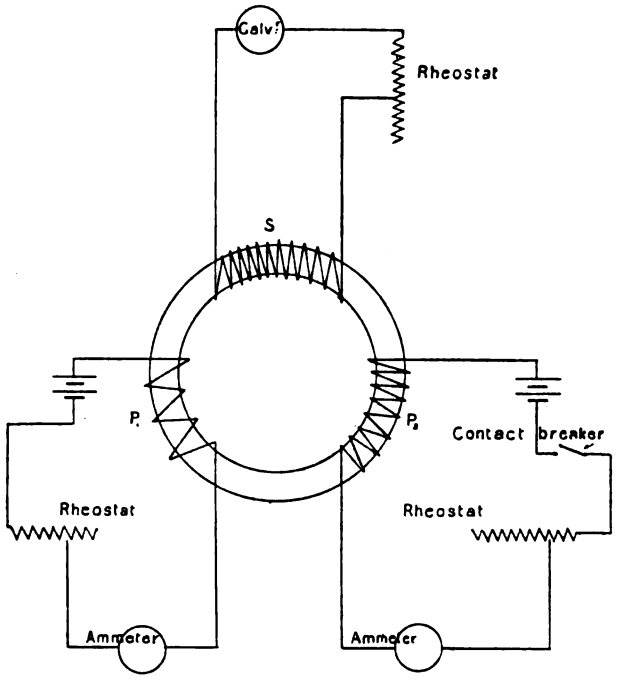

FIG. 1.—Arrangement of Apparatus for Testing.

To obtain the hysteresis curves, and to ensure the conditions being the same as in a transformer—that is to say that the magnetising force must always be carried from one extremity of the cycle to the point under observation at one fell swoop—we adopted the following method of winding.

The rings are generally about 13 cm. in diameter, and one or two sq. cm. in area; they are wound continuously all round with two primary coils, P_1 and P_2, and a secondary S is wound on, generally over the primaries for convenience, to produce the galvanometer deflection. One primary has preferably twice the turns of the other; in any case the currents must be so arranged that at the maximum the ampere turns on P_2 are twice those on P_1.

The arrangement of the circuits is shown in Fig. 1, where the coils are drawn separately for the sake of clearness; they really are wound over one another.

P_1 has say n turns, P_2 has $2n$ turns.

A current of some definite value, so arranged that the total magnetising force is of the dimensions required to keep the iron at the end of the cycle to be investigated, is kept up constantly in P_1; thus holding the iron at the negative maximum (0, Curve 1), when P_2 is not in action.

When a current of the same value, but in the opposite direction, is flowing in P_2 the iron is carried to its positive maximum, since P_2 has twice as many turns as P_1.

The mode of obtaining the curve is now obvious. Let Curve 1 represent the cycle under investigation. The "fiducial current" in P_1 is say 10 amperes; this current remains on all the time the cycle is being obtained, and is kept always accurately at the same value.

10 amperes are then put through P_2 in the reverse direction, and then broken; carrying the iron to the positive maximum, and returning to 0, the fiducial point.

The observation is then made by making a small current in P_2 (thus reducing the net ampere turns), and noting the deflection of the ballistic galvanometer. The ordinate A B is thus obtained.

The iron must then be again carried to the positive maximum, and back to O, by making and breaking 10 amperes in P_2.

The next point is obtained similarly, by making a somewhat larger current in P_2; this gives the ordinate C D.

Note that any observation can be repeated at once, which is often necessary, and which is impossible by the ordinary method.

Similarly the whole rising curve is obtained, the iron being put through its cycle between each observation, to remind it that it is a transformer.

The falling curve is of course similar, and may be obtained by reversing the currents in both coils.

Now, if this curve is obtained in the ordinary manner by successive jumps, first from O to A, then from A to C, and so on, the iron has time between successive observations to creep up along the curve from A to A' say, and the ordinate E' C is obtained at the next jump instead of E C. The sum of the deflections is then not great enough. Also the quantities passing through the galvanometer are not as great as they are in our method, and consequently the chances of error are greater.

Curve 1 is a curve obtained by our method, which shows its extreme value in the steep parts of the curve. Table 1 gives the actual values of the B and H (the induction density in kilo-gausses, and the magnetising force per centimetre of length in dynes), obtained by observation, and it will be noticed that even in the steepest parts the curve can be traced with absolute certainty, every observation being exactly on the curve.

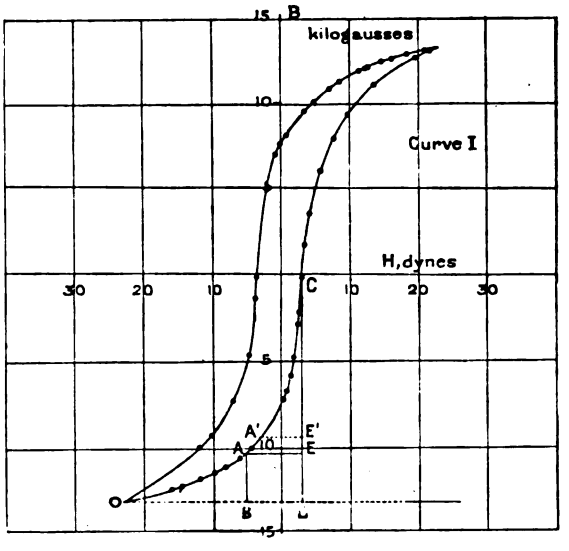

Table I.—*Wrought Iron, Unannealed.*

Rising.			Falling.		
No.	H	B	No.	H	B
1	−15·75	−12·5	23	+21·5	12·9
2	−14·5	−12·35	24	18·4	12·7
3	−11·4	−11·8	25	16·95	12·6
4	− 9·3	−11·4	26	14·9	12·3
5	− 7·9	−11·0	27	13·1	12·1
6	− 5·8	−10·4	28	12·8	12·0
7	− 4·4	− 9·8	29	11·4	11·8
8	+ 0·35	− 7·2	30	8·75	11·2
9	+ 1·0	− 6·6	31	7·35	10·8
10	+ 1·4	− 5·9	32	5·2	10·0
11	+ 1·9	− 5·0	33	3·7	9·5
12	+ 2·5	− 3·4	34	0·7	7·9
13	+ 2·6	− 2·9	35	0·2	7·6
14	+ 3·3	− 0·25	36	− 0·7	7·0
15	+ 4·0	+ 1·8	37	− 3·7	− 0·25
16	+ 4·7	+ 3·4	38	− 4·0	− 1·4
17	+ 6·3	+ 5·8	39	− 5·1	− 4·8
18	+ 8·2	+ 7·9	40	− 7·2	− 7·2
19	+10·3	+ 9·1	41	−10·3	− 9·4
20	+14·0	+10·9	42	−11·5	− 9·8
21	+19·3	+12·4			
22	+22·0	+12·9			

It has been asserted that the induction is unstable at the steep part of the curve; this is not so, as far as masses of iron are concerned, for we have never had any difficulty in stopping at any part of the curve and reproducing an observation. In connection with this subject of instability, I may mention another point which

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is noticeable. Prof. Ewing found that the residual induction in his soft iron wires was very unstable ; so much so, that a man walking in an adjoining passage caused enough vibration to shake all residual induction out. Mindful of this, we carefully tested our early rings for this effect ; while Mr. Evershed held the galvanometer switch over, I gently stroked the ring—nothing happened ; I tapped it lightly—still nothing. I ended by smiting it with a hammer, under which severe treatment it yielded up—2 per cent. of its residual induction! We concluded, therefore, that it required considerable *molar* vibration to affect masses of iron. It is not so with *molecular* vibration. A very small force applied by means of an electric current, either in the direction of the induction or at right angles to it, shakes out all residual induction.

There are two errors which must be looked for in all methods of measuring induction. First, air induction in the secondary, if it is larger in area than the iron ; this becomes of importance when the permeability of iron comes down near that of air, but may be neglected in most cases for small cycles, or calculated and allowed for. Secondly, unsymmetrical winding of the primary or primaries. We found that if a primary be wound half round a ring about 4in. across, 10 per cent of the induction leaked across through the air from end to end of the coil ; thus H cannot be calculated, owing to the unknown distribution of the magnetising force.

The advantages of the method described being so many, we finally decided to adopt it : and proceeded to manufacture our apparatus.

The ballistic galvanometer, of which details are given in Table II., appears to the naked eye a rough piece of apparatus, but it has performed its work admirably, and has never given us any trouble.

Table II.—*Ballistic Galvanometer.*

Length of needle = 4·8 cm. Sect. area = ·0726 sq. cm.
Period = 3·8 seconds.
Resistance = 69·6 B A ohms at 20°
Max. angle of deflection = 9°

My audience must remember that all these experiments were carried out in engineering works, and not in a laboratory ; and this fact made us anxious to eliminate every source of error. We had to devise a ready method of standardising the galvanometer every time we used it, as motors and dynamos in the immediate neighbourhood are not conducive to constancy in the earth's field.

We therefore made a solenoid of length 120 cm. and diameter 3 cm. Its length being great compared with its diameter, the field at its centre could be accurately calculated, from the well-known formula

$$\mathbf{H} = \frac{\cdot 4\pi C N}{l}$$

where C is current in amperes, N the number of turns, and l the length.

Assuming that the permeability of the broomstick on which the solenoid was wound to be the same as that of air

$$\mathbf{H} = \mathbf{B}$$

we thus get the number of Thoms per unit of area at the centre of the coil.

The secondary, wound inside the solenoid in a groove in the broomstick, had 1,000 turns of very fine wire. Its average area was 5·0 sq. cm.

$$\mathbf{H} \times \text{area} = \frac{\cdot 4\pi C N}{l} . a$$

gives the induction cutting the secondary.

This broomstick standard thus gives us a means of calibrating our galvanometer as well as standardising it.

The theory of the ballistic galvanometer given in text books says, that the induction is proportional to the throw, under certain conditions, one of which is that if there is damping, corrections must be made by means of a "logarithmic decrement." We did not quite know what a logarithmic decrement was, and so we preferred to try whether our scale was a straight line, by going to the *fons et origo* of all knowledge, experiment.

$$\theta \propto \frac{1}{R}$$

if $\mathbf{B} \times$ area is kept constant ; where θ is the throw, R the resistance of the circuit, and B the induction density. Then we took a curve of B and θ for constant resistance and turns, and this curve cannot be distinguished from a straight line.

If, therefore, all deflections are taken with the same resistance in circuit, the formula is

$$\theta = \frac{a n}{R} (\mathbf{B} \times \text{area})$$

where a is a constant depending on the galvanometer.

Owing to the variation of the amount of damping with the resistance of the secondary circuit, this formula is not true (except at the resistance at which the galvanometer was standardised), unless the damping be properly allowed for.

Deflections taken at various resistances can be made comparable with one another, by substituting for them uniformly the value they would have had, if some fixed resistance (infinity for convenience) had been in circuit.

A curve of coefficients, by which throws at various resistances must be multiplied in order to reduce them to "throw on open circuit," is easily obtained.

A fixed impulse is given by means of an external coil by tapping a key, and the deflection noted for open circuit, and for various resistances. The damping increases as the resistance of the circuit decreases, and the percentage difference from the throw at infinite resistance is thus obtained. This curve is shown in Fig. 2. By

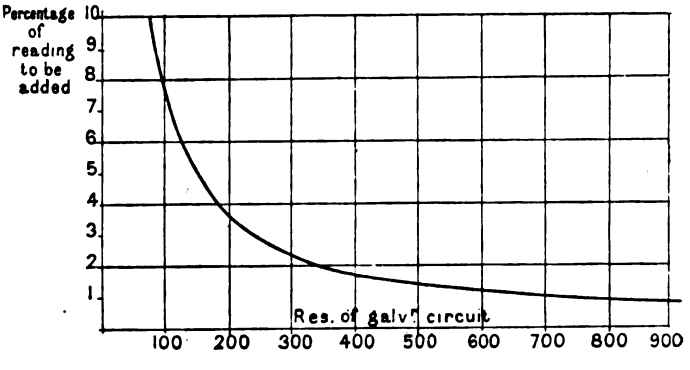

FIG. 2.—Ballistic Galvanometer Damping Curve.

means of it all throws can be reduced to throw on open circuit by multiplying by the required percentage. The curve is a rectangular hyperbola.

We are now prepared to standardise the galvanometer.

Since $$\theta = \frac{a n}{R} (\mathbf{B} \times \text{area}),$$

the induction $= \mathbf{B} \times \text{area} = \frac{R \theta}{a n}$;

whence we see the $\frac{1}{a}$ or g, the galvanometer constant is to be obtained. Now,

$$g = \frac{1}{a} = \frac{R \theta}{n \mathbf{B} \times \text{area}},$$

and thus one deflection from a known B in the broomstick gives the required constant.

Any mutual induction coil may be standardised by means of the solenoid, and used as a standard in place of the somewhat clumsy broomstick.

In our "Mutual Inductioner," 1273 Thoms cut the secondary for 10 amperes in the primary. Everything was now ready, except that all-important item in a research, the elimination of "niggers." I may mention some of these, in case any of you ever have to investigate force-induction curves.

It is necessary to break the primary *very* sharply. We had much trouble from double-breaks until we made a "jumper," in which a copper wire filed to a point was pulled from a mercury cup by elastic. This arrangement is perfectly satisfactory.

Bad contacts in the secondary circuit are a fruitful source of error when working with low resistances. We have made a rocking mercury-cup switch, which when put over to the left, throws the ballistic galvanometer into circuit, and when over to the right short circuits the galvanometer, and puts the remainder of the circuit on to the bridge, so that its resistance can be taken if necessary before or after each deflection, since the resistance alters by heating. To avoid these errors, wind many turns of secondary, so as to have *large* resistances in circuit ; in this case the heating of a secondary of a few ohms does not matter.

A great many errors may be due to the currents in the primary circuit affecting the ballistic galvanometer directly. We leave our leads long, and can then raise, lower, or coil them up, till currents in them do not affect the galvanometer. This point is most important, especially with large primary currents. These "niggers" having been discovered and eliminated, we were in a position to begin our research.

(To be continued.)

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LEGAL INTELLIGENCE.

The Jablochkoff Patent.

The resumption of the argument in favour of confirmation and prolongation of the Jablochkoff distribution patent, No. 1,996, of 1877, came before the Judicial Committee of the Privy Council on Wednesday last, the Committee being represented on the occasion by Lord Watson, Lord Morris, Lord Hobhouse, and Lord Shand.

The Attorney-General (Sir Richard Webster) and Mr. Sutton appeared for the Government to oppose the petition. Mr. Moulton, Q.C., who had the petitioner's brief, being ill with influenza, the petitioner's counsel were Mr. Roger Wallace and Mr. Renton.

The application of the petitioner, it will be remembered, was for a confirmation and extension of time for his patent.

The ATTORNEY-GENERAL said it was his duty to oppose both the petitions. The general grounds of his opposition had been submitted to the Court, but there was one point he was not in possession of at the last occasion. By paragraph 4 of the petition it was shown that Mr. Jablochkoff obtained patents in France, Belgium, Germany, Italy, and the colony of Canada for the same subject-matter of invention, but the dates of those foreign patents were not stated. The Attorney-General said he found that some of those patents were taken out prior to the date of the English patent. On May 22, 1877, there was a patent issued in England, but on November 30, 1876, there was the French patent—that was to say, a year and nine months before the English patent. That French patent was alleged to be still in force, but he was informed it would expire in November of this year. Then the Belgian patent was also taken out before the English patent—viz., on February 6, 1877, and which expired on October 8, 1888. He would have to refer, on the merits, to two others—one taken out in Germany on August 14, 1877, and which lapsed in 1883; and the other taken out on May 25, 1877, or three days after the English patent, which also lapsed in 1883. He did not especially refer to those two at that moment, though he thought they brought a serious difficulty in the way of his learned friend (Mr. Wallace). Their Lordships would be aware that the petitioner was proceeding under the repealed statute of 1883, by virtue of the saving clause. If their Lordships would look at section 25 of the Patent Law Amendment Act of 1852 they would see that where an earlier patent was taken out in a foreign country, and was allowed to expire, the English patent died with the same period. Therefore, unless his learned friend had some answer, based on the Act of 1883, that was a fatal objection so far as the Belgian patent was concerned. Continuing, the learned gentleman said the only point for the petitioner could be that, because the Belgian patent did not expire till 1888, the Act of 1883 having repealed the earlier statute, therefore the bar was not total in that case; but, by anticipation, he was obliged to submit that that could not be an answer.

Mr. ROGER WALLACE (for the petitioner) said he did not dispute the cases his learned friend had read, so far as the patents to which they applied. He did not dispute that the foreign patents were taken out before the date of the English application, so that he could not argue that he came within the wording of the 25th section of the broad Act, 15 and 16 Vict., c. 83. But he did submit that the Act of 1883 did preserve to the petitioner the right of claiming the benefit of confirmation of his letters patent, and that the objections before the Act of 1883 did not apply.

After a long argument the room was cleared for their lordships to confer.

JUDGMENT.

Lord WATSON delivered the judgment of the Committee as follows:—There are two separate applications in regard to this patent; in one their Lordships are invited to recommend that the patent be confirmed under the terms of the second section of the Act 5 and 6 William IV., c. 83; and in the other to recommend the prolongation of the patent for such term as shall seem to them to be just. The English patent bears date May, 1877, but in the same year at a previous date, viz., on February 6, 1877, the same invention was secured to the patentee in Belgium. And that right or privilege was declared to have lapsed by the Royal decree on October 8, 1888. It is conceded in argument by the petitioner that no application for confirmation of patent can be made under the Act of 1883, and that statute abolished the Act of William already referred to, but the Board are still in a position to entertain petitions for confirmation by virtue of the provisions of the 113th section of the statute, which saves a portion of the Act in so far as it relates to patents which were in force at the time when the statute of 1883 became law. If the Act of William stood alone, the case of the petitioner would be comparatively plain, but the powers of confirmation which were conferred by the statute were qualified by the Patent Act of 1852, the 25th section of which enacted that in the case of an English patent, where a previous patent for the same invention had been taken out in a foreign country, the patent should cease, and be void immediately upon the expiration or other determination of the term during which the patent or legislative privilege obtained for such foreign country shall continue in force. If that qualification still applies to the right—the patent right—of the petitioner, there is an end of this case, because his patent lapsed in 1888 along with the Belgian right, in the terms of the statute. But the argument that has been addressed to their Lordships has been to this effect—that whilst section 25 of the Act of 1852 is wholly repealed in so far as regards this patent, section 2 of the Act 5 and 6 William is kept alive in his favour. Now that is founded upon the provisions of the sub-section 1 of section 113 of the Act of 1883, which appears to their lordships on consideration to be fatal to the contention addressed to them. The saving clause in favour of the patent in force at the date of the statute is in these terms. In section 1 it is declared that the repeal of the previous enactment shall not date to the past operation of this enactment for any patent, or right, or privilege, or obligation, or liability acquired, approved, or confirmed under any enactment before or at the commencement of the Act. Now it appears to their Lordships that at the date when the statute of 1883 was passed there was, incidental to the right of the patentee or his assigns in possession of the capital before us, first a right to confirmation, should it be necessary, under the Act of William; but in the second place a liability on their right, to be determined in the event of the lapse of the Belgian patent. These were a right and a liability which had arisen and formed part of the law of patents at that date. And it certainly does appear to their Lordships that, looking at the language employed by the Legislature, which saves all obligations and all liabilities attaching to the patent, as well as all rights to the patentee, it is impossible for them to affirm that the Legislature meant to retain to the patentee his rights where older than the statute, and right to confirmation, without a corresponding qualification introduced by the legislation of 1852. And, therefore, it appears to them that the petitioner here cannot appeal to the provisions of the Act 5 and 6 William IV. without submitting at the same time to the qualifications of the statutory rights there introduced by the Patent Act of 1852. Therefore the application must be dismissed.

There remains the petition for extension of the patent, which may be very shortly dealt with. As regards the application, the petitioners are in this dilemma—that if it be presented as a petition, presented in terms of the recent Act, the answer is conclusive—that the statute does not apply, because it was not presented more than six months before this natural currency of the patent came to a close. And the other alternative is that it is an application under the old law; and if it is an application under the old law, the provisions of the 25th section of the Act of 1852 are as fatal to the power of this Board to deal with extension as those provisions were fatal to the application for confirmation. Therefore this petition must also stand dismissed.

In re Institute of Medical Electricity.

Mr. JUSTICE CHITTY, on Wednesday last, dismissed a petition for winding up this Company.

Mr. Byrne, Q.C., and Mr. Le Breton appeared for the petitioner; and Mr. Farwell, Q.C., and Mr. Lawson for the Company.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *May* 1, 1891.

Edison Slow-Speed Tramcar Motors.—At last the much-heralded Edison slow-speed street car motor has put in an appearance, and so far as can be judged from rather complete descriptions, it is possessed of no strikingly valuable characteristics, or unusual details. It is a four-pole machine of ironclad form, having a large Gramme armature. The pattern is not widely different from that of the Wenstrom-street railway motor, but, so far as can be judged from appearances, the amount of iron employed is very scanty considering the fact that the field magnets are castings. The two salient poles are of dubiously small cross-section, and the magnetising coils T-shaped, very flat, and of dimensions that bespeak danger of heating. The armature is a Gramme ring 18in. in diameter and 13in. on the face, built up of soft iron stampings, supported on a aluminium bronze spider. The armature is wound with a continuous wire, and its principal peculiarity is that the leading wires to the commutator are made of German silver. This is said to be for the purpose of reducing the induced current where the brushes are short circuited, and hence diminishing sparking. Inasmuch as a properly constructed motor shows no appreciable sparking from this cause one is led to the conclusion that either the advantage gained is purely fanciful, or that the motor possesses electrical characteristics such as render something of the sort absolutely necessary. The armature spindle has a pinion at each end, meshing into the gears on the car axle, so that, although there is but a single reduction speed by gearing, the same number of wheels to wear and rattle are provided as in the old Edison motor. The wearing, of course, is somewhat diminished, but the gears are there. Another peculiarity of the new Edison machine is the use of four carbon brushes, a feature that hardly commends itself to the practical street-car man, and seems totally unnecessary in the present state of electrical designing. The speed of the new motor is reasonably slow, about 460 revolutions per minute, at a car speed of 12 miles per hour. The method of regulation employed is the same as that which has displayed its virtues and vices in the old Sprague motor. Each of the two magnetising coils is divided into three sections, which are commutated by a switch box similar to that the Edison Company has previously used. Altogether the new machine is somewhat disappointing. It looks as though the

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field coils are likely to be worked rather harder than is conducive to long life. The resistance of the motor is judiciously not stated.

The Westinghouse Company.—The annual meeting of the Westinghouse Company will be held next Monday, and then the public will probably know something about its financial status. From all appearances the Company has, through the efforts of Mr. Westinghouse, been extricated from its difficulties quite successfully, and will prove no small factor in the construction work of the coming season. The railway department proposes to push the Westinghouse gearless motor very actively, and a few weeks will probably see roads equipped on this system under actual operation. What with the coming gearless and single-reduction-gear motors electric traction work during the summer will be of unusual interest. These new machines have only been tried in a somewhat limited experimental way, and it will probably take some bitter experience to bring them into first-class working condition. There is a tendency to work copper altogether too hard in the attempt to secure low speed, and it is not unlikely to cause breakdowns in some of the early roads. Still, the gearless or singly geared motor is sure to come, and eventually it will crowd out the older forms; but these types are likely to be perfected only through actual experience.

CORRESPONDENCE.

THE CITY AND SOUTH LONDON RAILWAY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Everyone connected with the electrical profession wishes well to the City and South London Railway, and I therefore wish to give the management a hint, which may have more effect if given through your columns than if sent direct, and which, if acted on, will, I feel sure, save them claims for damages.

I refer to the lighting of the stairs leading to the trains. At the Monument and Stockwell this is fairly adequate, but at the intermediate stations—the Oval, for example—the lighting is altogether insufficient. Going in from the bright sunlight, the greater part of the stairs appear to be absolutely dark, and one has to grope one's way with the utmost care to avoid a serious fall. Being spiral, the stairs require a number of lights, and the fact that they are spiral makes them all the more dangerous.

Then, again, sir, can nothing be done to improve the lighting of the carriages? At present it is most tantalising to anyone trying to read. Sometimes the light vanishes entirely, while every now and then it drops to a dull glow, making reading impossible. It should surely not be beyond the resources of science to apply the electric light satisfactorily to railway carriages on an electric railway.—Yours, &c., R. N.

TRADE NOTES AND NOTICES.

"THE ELECTRICIAN"

ELECTRICAL TRADES' DIRECTORY & HANDBOOK for 1891.

The 1891 edition of our well-known Directory and Handbook is ready, price 5s., postage extra. The book consists of over 900 pages, and has entailed this year a heavy amount of work. The HANDBOOK DIVISION contains a mass of most useful information. The DIRECTORY DIVISION consists of 430 pages, and contains a very carefully compiled Alphabetical and Classified List of Firms and Persons engaged in the Electrical and Allied Trades in all parts of the world. This Division has been corrected up to date, and the book is thoroughly reliable, the very numerous changes which take place at the beginning of the year being incorporated. By the aid of this Directory, makers of Electrical Machinery, Apparatus, Instruments, Fittings, Sundries, Novelties, and other goods, may safely communicate direct with probable customers without the annoyance and great expense consequent upon using books which are mere lists of Members of Scientific Societies repeated again and again. The Colonial and Foreign Division of this Directory will be found extensive and reliable. *Orders should be forwarded at once.*

In the course of a few weeks "The Electrician" Company will publish "THE ELECTRICIAN" PRIMERS in two volumes, price per volume 2s. paper covers, 2s. 6d. cloth.

TENDERS INVITED.—The Romford Local Board of Health invite tenders for lighting the public lamps by electricity, gas, or other illuminant; as to a portion (123), during a period from August 10th next to June 10, 1892; and for a further portion (10) for 12 months from September 1st next. Tenders, which should include cost of lighting, cleaning, and repairing, should be sent in to Mr. A. W. Hunt, the Clerk to the Board, on or before 4 o'clock on Monday, June 1st. Some further details will be found in our advertisement columns, and full particulars may be obtained on application to the Surveyor of the Board.

——— Tenders are invited by the Gas Committee of the Manchester Town Council for the lighting by electricity of the Town Hall. Tenders are to be divided under two heads—(1) To supply and fix the whole of the fittings and all necessary connections and appliances required to light the various rooms and corridors; (2) To supply and fix the motive power, such as gas engines, dynamos, and all plant, &c., necessary for the production of the electric light. The rooms, &c., to be lighted will be pointed out on application to the Steward. Further particulars may be obtained from the Town Clerk, and tenders, addressed to the Chairman of the Gas Committee, must be delivered at the Town Hall by June 17th.

——— The Clevedon (Somerset) Local Board are, as will be seen by our advertisement columns, desirous of receiving tenders for the public lighting of their district for one, two, or three years; and tenders are to reach Mr. H. C. Fry, the Clerk, on or before June 2nd.

——— Mr. Dun. Cameron, architect, of Inverness, invites specifications and tenders for the electric lighting of Corrimony Mansion House, Glen-Urquhart, Inverness-shire. Particulars will be found in our advertisement columns.

——— The Barnet Local Board invite tenders for lighting their district for terms of three, five, or seven years. Particulars may be obtained of Mr. H. W. Poole, Clerk, 18, High-street, Barnet, to whom tenders are to be sent not later than the post first on May 19th.

——— The Directors of the Great Eastern Railway Company are prepared to receive tenders for the supply of telegraph materials, india-rubber, &c. Patterns may be seen at the Stores, Stratford. Forms of tender are to be obtained at the Secretary's office, Liverpool-street Terminus, E.C., where tenders are to be forwarded on or before 10 a.m. on May 23rd.

ELECTRICAL ENGINEERING CORPORATION (LIMITED) (IN LIQUIDATION).—Claims against this Corporation must be forwarded to the liquidator, Mr. F. W. Pixley, 24, Moorgate-st., E.C., by June 6th.

MAXIM-WESTON ELECTRIC COMPANY (LIMITED).—Claims in respect of the old Company must be forwarded to either of the liquidators, Messrs. John Marks, 113, Great Russell-street, Bloomsbury, W.C., and Louis Swaby, 23, Churchfield-road, Ealing, and claims in respect of the new Company must be forwarded to either of the liquidators, Messrs. John Marks, as above, and James Hodgson, 17, Little Trinity-lane, E.C.—in each case by May 31st.

WOODHOUSE AND RAWSON UNITED (LIMITED).—This firm sends us particulars and prices of the Epstein accumulator, of which they are the sole manufacturers and suppliers. Accompanying this information are some illustrations and particulars of hydrometers and the W. and R. patent cell tester.

MESSRS. OSBORNE AND CO.—This firm announce that they have started in business at Pleasant-place, Essex-road, London, N., as electrical and chemical engineers. They are bringing out a new form of primary battery.

MAGNOLIA METAL.—In consequence of the largely increased sales of magnolia metal during the past year the Magnolia Anti-Friction Metal Company beg to announce that they are enabled to quote the following cash prices, to take effect May 1, 1891, and until further notice:—For quantities of one ton and over, £112 per ton; 5cwts. and over, 1s. 1½d. per lb.; in less quantities, 1s. 3d. per lb. Magnolia is packed in 46 and 112lb. boxes each.

THE HENRY DRY CELL.—The General Electric Company are bringing out a new dry cell which is made up in two very neat forms, one with a black glass jar, and the other with an oblong composition cell. They are also arranged in boxes for use with small lamps, testing, &c. We hope shortly to give further details as to their capabilities.

ANNUAL DINNER GRATUITIES.—We are pleased to receive from the Edison and Swan United Electric Light Company a note that the Directors have had brought before them the very reprehensible practice of soliciting for subscriptions to their *employés'* annual excursion. The Directors most strongly disapprove of the practice, and they have issued an order, upon the terms of which we congratulate them, that any *employé* of the Company so soliciting will be dealt with summarily, and that firms who supply materials to the Company offering any gift of money or present will be struck off the Company's list. We shall be pleased to extend our congratulations.

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PATENT RECORD.

APPLICATIONS FOR PATENTS.

April 21, 1891.

6,906. G. WILKINSON. London. Improvements in arc electric lamps.

April 22, 1891.

6,908. J. MCLAREN. Edinburgh. An electro-magnetic gas controller.

6,963. C. E. SPAGNOLETTI. London. Improvements in means for staying telegraph signal, and other posts or masts.

6,978. A. J. BOULT. London. Improvements in or relating to the automatic regulation of dynamo-electric machines. (William Stone, Australia).

7,009. W. R. WYNNE. Newcastle-on-Tyne. Improvements in electric bells.

7,010. W. R. WYNNE. Newcastle-on-Tyne. Improvements in electrical mining keys, &c.

April 24, 1891.

7,075. E. H. ROYCE. Manchester. Improvements in incandescent electric lamps, holders, ceiling roses, and other like fittings.

7,080. A. WILBAUX. London. Improvements in or connected with the manufacture of wall or other coverings, artificial leather, electrical insulators, boxes, and other articles, from vegetable parchment.

7,085. T. COAD. London. Improvements in portable electric lamps.

April 25, 1891.

7,126. H. JENSEN, J. JENSEN, and WOODHOUSE AND RAWSON UNITED (LIMITED). London. Improvements in electric lamp suspension fittings.

7,127. H. JENSEN, J. JENSEN, and WOODHOUSE AND RAWSON UNITED (LIMITED). London. Improvements in apparatus for indicating the proper working of electrical bells, annunciators, and the like.

7,160. F. WALTER. London. An improved method of producing a hermetical seal for the connecting wires of the filaments of incandescent lamps.

7,167. T. HARDEN and F. E. PEARL. London. Improvements in electric arc lamps.

7,174. G. S. GRIMSTON and E. PERRETT. London. Improvements in electric arc lamps.

7,178. C. J. HALL and R. HAMMOND. London. Improvements in dynamo machines.

April 27, 1891.

7,204. W. KINGSLAND. Chiswick. Improvements in electric alarms.

7,210. G. A. JARVIS. Wellington. The manufacture of improved incandescent lamps.

7,217. W. E. LANGDON. Derby. Improvements in fittings for telegraph poles.

SPECIFICATIONS PUBLISHED.

1890.

7,487. FREEMAN. Electromotors. (Price 8d.)

9,261. HEADECH. Electric arc lamp. (Price 8d.)

15,442. MCCLUER. Electric telephones, &c. (Price 8d.)

1891.

3,338. PARKER. Telegraphy. (Price 8d.)

3,589. LAKE (Dowse). Electric batteries. (Price 6d.)

3,740. KOECHLIN. Electric meters. (Price 8d.)

3,867. KENNEDY. Electricity meters. (Price 6d.)

4,271. NEWTON (American Electric Railway Signal Company). Electrical railway signalling. (Price 8d.)

COMPANIES' MEETINGS & REPORTS.

Chelsea Electricity Supply Company (Limited).

The Ordinary Annual General Meeting of the Chelsea Electricity Supply Company (Limited), was held at their Central Station, Draycott-place, Sloane square, London, yesterday. The chair was occupied by J. Irving Courtenay, Esq.

The SECRETARY (Mr. S. J. Cluer) read the notice calling the meeting, and the report of the Directors was taken as read.

The CHAIRMAN then said: Gentlemen, when we met last year the profit and loss account presented to you was for one quarter of the year only, and that the quarter of heaviest demand. There was then shown a small balance to the good, but no Directors' fees had been paid. The amount received for current sold during 1890 was £6,067. 6s. 10d., and the gross profit shown in the accounts before you is £542. 19s. 5d. I may mention that the receipts for the March quarter in this year amounted to £3.275. But you will bear in mind that, although we are now supplying current to over 22,000 lamps, as against 10,000 this time last year, the increasing revenue in respect of these lamps was only even partially felt in the last quarter of the year 1890; and, moreover, the profit on the year's work has been made in spite of most disadvantageous circumstances, which I will now deal with. I allude to the question of heavy consumption of coal mentioned in the report. I regret to say that the consumption during the year has been excessive; but I am glad at the same time to be able to inform you that the unceasing attention to the subject on the part of the management has resulted in the certainty of a reduction of the cost of producing the current as soon as the rearrangement of plant, now in hand, is complete. As the subject is still under discussion, it is not permissible for me at the present moment to say where, in our opinion, the fault lies, but I sincerely hope that an amicable settlement of the difference will be arrived at. There is another point I must touch upon, because it has been the subject of some misrepresentations. Owing to non-delivery of machines, which were ordered early in the year to provide for the winter supply, we were compelled on a few occasions in December, when a heavy drain came upon us through continued foggy weather, to shut off our supply of current for a few hours only in the day time. Some of the plant having shortly after arrived, the constant supply was resumed on December 24th, and maintained throughout the remainder of an exceptionally foggy winter. Now, unfortunate as this undoubtedly was, it still showed the advantages of the storage system; for, instead of stopping the supply suddenly, as might be the case without storage, we were able to give a full day's notice that we should cease supply for a few hours in the daytime, and thus prevented serious inconvenience to our customers. We may congratulate ourselves that we have still the record of not having once stopped supply of current during the hours when light is generally required, and I may also here add that our customers continue to express their entire satisfaction. You will find in the profit and loss account an amount of £253. 6s. 3d. for maintenance of plant. This is made up of small repairs to the different kinds of generating plant, instruments, and tools, and about £50 in wages to men cleaning out the accumulator cells. No expenditure was incurred in 1890 in replacing the E.P.S. storage battery plates, and up to the present day, only one set out of 1,918 sets has had to be replaced, and that at a trifling cost. Now, it must be borne in mind that the replacing of a set of plates is not merely maintenance, as in the case of repairs to a steam engine, but is a complete renewal of the cell, as the other parts for all practical purposes suffer no deterioration. The mains of the Callender Company have also fulfilled our expectations, and have not cost us anything for the repairs of cables. Some of the cables have been underground for over two years, and, from tests taken periodically, it is found that they are still in perfectly good condition. The E.P.S. accumulators are for the first time being used in sub-stations under the direct supervision of our engineer, and so well have they performed their duty that it is difficult, even now, to settle what is a proper amount to set aside for their depreciation. It is intended, however, as stated in the report, to maintain a renewal fund out of profits in order to provide for exceptional outlay in any one year. You will have noticed a printer's error in one of the figures of the balance-sheet, where the figure 9 appears instead of the figure 6. It should be 1,648 shares, and not 1,948 shares. It does not affect the money column. I now come to the present state of the business, and its prospects. You will see by the balance-sheet that the plant has been increased by the amount of £14,660. 10s. 6d. The mains and the generating and storage plant have all had a share in this increase, but the greater part of it is to be found in the extensions of mains, and the erection of a new storage station in Pavilion-road. These additions, together with the plant ordered this year, will enable us to supply sufficient power for about 36,000 8 c.p. lamps installed, which, at the rate of 8s. per lamp installed, would represent a gross income of £16,000 per annum; but this increase would involve the extension of our mains as found to be necessary. Nine shillings per 8 c.p. lamp installed is the figure upon which our experience shows it is prudent to place our estimate of income. I am aware that this is a somewhat lower yield per lamp than that of companies in whose area of supply theatres, hotels, clubs, and shops are numerous, but the shops in Chelsea are now also coming on our list of customers. I think, however, it will be found in practice that the above figure fairly represents the yield per 8 c.p. lamp in domestic lighting. Our district is an excellent one. There is no part of the metropolis where rebuilding is more continually going on, and very few houses indeed in this neighbourhood, as you are aware, are built without being wired for the electric light. We have had added to our area of supply by the Board of Trade a very large portion of the parish of Chelsea, containing about 4,500 houses, including several localities favourable to the development of the business. I do not, however, wish to put before you a too sanguine view of our prospects. I have, therefore, had a careful estimate made of the probable increase during the year in the number of lamps to be supplied, and the result of inquiry points to our reaching a total of 35,000 lamps installed, provided we make the extensions referred to. It is a matter of satisfaction that during a year of financial tightness, and even panic, we have been able to place all the debentures we offered—viz., £20,000—at a moderate cost. The money thus obtained has been carefully dealt with in the most economical manner, and, by means of the new plant already obtained and that on order, we can confidently look forward to a considerable economy in the working during the latter half of the present year. As has been mentioned in the Directors' report, it will be necessary to provide funds for the extension of the mains and for additional plant to meet the increase in the Company's business, and after full consideration the Directors have resolved to recommend an issue of preference shares bearing 6 per cent. interest, and for the present to defer any further issue of debentures. We propose to take power to convert £30,000 of the unissued ordinary share capital into preference shares. This fresh capital will be called up gradually, as required. When this expenditure has been made, the total issued capital of the Company, including debentures, will be about £92,000, or, in other words, the total capital outlay of the Company, including the cost of all stations, cables, and plant, will be, say, £2 12s. per lamp fixed. These figures will compare favourably with those of other Companies, especially when it is remembered that our conduits have a carrying capacity for double the number of lamps I have mentioned.

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I am prepared to give any further information that may be required, subject to the remarks made at the beginning of my speech. I beg to move the adoption of the Directors' report and statement of accounts.

The DEPUTY-CHAIRMAN (Major-Gen. Webber, C.B.): I have very great pleasure in seconding the motion.

The CHAIRMAN invited discussion, but no one rising to address the meeting, he put the motion, and it was carried unanimously.

The DEPUTY-CHAIRMAN then proposed, and Mr. KING seconded, the re-election of the retiring Directors, Mr. Courtenay and Sir George Prescott, Bart., and the motion was carried unanimously.

The CHAIRMAN, on behalf of himself and Sir George Prescott, thanked the shareholders for re-electing them. He had just received a telegram from Sir George Prescott expressing his great regret at not being able to be present, as he had fully intended to be with them.

On the motion of Mr. SHARP, the retiring auditors, Messrs. Cooper Bros. and Co., were re-elected.

The CHAIRMAN: The next business relates to the issue of fresh shares, in accordance with what I have already said—that we should carry out extensions and add to our plant and so increase our income, and, indeed, fulfil our statutory obligations to give the light to those portions of our area and supply where at the present moment our mains do not extend. I therefore beg to propose the following resolution:—

"*That of the unissued capital of the Company, now amounting to 11,512 shares of £5 each, 6,000 shares of £5 each, and numbered 14,001 to 20,000 inclusive, shall be, and the same hereby are, created and made preference shares, and that such shares shall confer on the holders thereof the right to be paid out of the profits of each year a preferential dividend for such year at the rate of £6 per cent. per annum and no more, and every holder of preference shares shall have one vote for every preference share held by him.*"

Mr. EMILE GARCKE seconded the motion.

Mr. EARNSHAW asked whether any idea could be given to the ordinary shareholders as to when they were likely to receive a dividend.

The CHAIRMAN: I believe the figures we have given in the report answer the question of the honourable proprietor as far as I am able to. The earning capacity of the Company, when these improvements are carried out, and with this fresh capital issued, will represent, I believe, the figures we have mentioned, which are the best estimates that our engineers and others can give us. Our capital is comparatively light for the amount of lamps we shall then have, and though our yield per lamp is not so high as in the case of other companies, still I think it is a fairly safe estimate that our income will amount to £16,000 per annum. It is always very dangerous to prophesy, because it may come back upon one, but I think and believe that when we have carried out these extensions, our fixed charges not being very heavy, and when we are in full swing, the ordinary shareholders will derive some benefit.

Mr. EARNSHAW stated that the gross profit mentioned in the report for the year was £542, but that had been swept away entirely.

The CHAIRMAN: But it is very different when you are dealing with large figures. The whole amount we had to deal with last year was £6.000—a very different amount from an estimated figure of £16,000, because a great many of the fixed charges will remain pretty much the same, and when you deal with a much larger income then will come in the profit. The gross revenue for the first quarter of this year is equal to one-half of the whole amount received last year: and we hope, and it is our belief, that our income will grow in that way, while our expenses should not increase.

A SHAREHOLDER asked for some information with respect to the extension of the business in the last three months in the current year.

The CHAIRMAN: In the latter part of the year our increase was very slight. In fact, we stood still, and we had to stand still. We were not pushing our business in the last portion of the year, because, as I have mentioned, we had at one time to stop the supply, though only for a short time. We were not, however, able to push our business as we should have done had we had the current; and until we get additional plant we dare not push our business. It is far better to keep up our reputation and satisfy our customers than increase the number of our supplies until we are ready to do so, as we should thus have complaints. He then put the motion, which was carried unanimously.

The DEPUTY-CHAIRMAN: I do not think the Chairman omitted the caution which is necessary for anyone in his position to observe, but I think it may fairly and justly go out from this meeting that when we reach the point of earning £16,000, if our expenses and general charges amount at the outside to £9,000, while our obligations towards the debenture holders and preference shareholders amount to £3,000, there is a good £4,000 a year to divide among the ordinary shareholders. I derive, and, as a large shareholder in the Company, I hope that those present will derive the same, comfort from that prospect as I do myself.

On the motion of the Rev. W. J. STOBART, a vote of thanks was passed to the Chairman and Directors.

The CHAIRMAN acknowledged the vote; and subsequently, in reply to a question, stated that it would have been quite as convenient for the Directors to have met the shareholders in the City. Their object, however, in holding the meeting at Chelsea was to enable the shareholders to see the station. The question of meeting in the City was a matter entirely for the shareholders.

The proceedings then terminated.

The following is the Directors' report:—

The accounts are not issued in Board of Trade form, because that course would involve two separate balance-sheets (one for Chelsea and one for Kensington), which would be confusing to the shareholders. This is the subject of correspondence with the Board of Trade, and, when the matter is settled, the accounts will at once be put into such form as that department may require.

The steady progress of the business during the year is very satisfactory. On December 31, 1889, 93 customers, or an equivalent of 8,730 lights of 8-c.p., were being supplied; while on December 31, 1890, there were on the books 252 customers, with lights installed equivalent to nearly 20,000 lamps of 8-c.p. The Company has received for current sold and meter rents in 1890 the sum of £6,067. 6s. 10d., and, after deducting all working expenses, there remains a gross profit of £542. 19s. 5d.

The consumption of fuel in the year 1890 has been excessive; but this is believed not to be due to any defects in the Chelsea system, and measures have been taken which it is hoped will prevent its continuance.

The rate at which the revenue has increased is best exemplified by comparing the two heaviest quarters of the year. In March quarter the receipts for current supplied and meter rents amounted to £1,275. 12s. 3d., and in December quarter to £2,872. 17s. 6d. This affords an indication of the rate of increase of revenue in 1891; and, as the profits should be more than proportionately augmented, the prospects for the current year are favourable.

Under the authority given at the last general meeting, the Directors resolved to issue £20,000 of Six per Cent. Debentures, the whole of which has been subscribed. This has enabled the Directors to repay the loan from its Bankers, and to complete the extensions in hand last year, including new mains and the new storage station in Pavilion-road.

In view of the further extensions necessary to occupy the areas within the Company's districts, the Directors have decided, in lieu of issuing any further debentures at present, to recommend an issue of preference shares, and, with this object, a resolution will be proposed at the general meeting of the Company.

The completion of the plant in accordance with the original plan of the central station in Draycott-place is in progress, and, when the work contemplated for the year has been done, the stations will be capable of earning over £100 during average lighting hours in one day. The experience gained by the Company shows that, under the varying conditions of demand throughout the year in this district, this earning capacity may be estimated to yield a gross revenue of about £16,000 per annum. After paying all outgoings, including the cost of upholding the plant and interest on debentures, the balance should afford satisfactory dividends on the share capital.

The mains, consisting of Callender's Bitumen Cable, of which about 20 miles have been placed underground, are regularly tested, and the results continue to be most satisfactory on all the cables, including many which have been underground for two years. None have had to be renewed on account of defects.

The accumulators are all in good working order. Those at Clabon-mews storage station, which have been longest in use, *i.e.*, for two years, are in excellent condition, and it has not as yet been necessary to replace any of the plates.

The Directors have not dealt with depreciation in these accounts; but care has been taken to keep up all the plant to its original working efficiency. The storage batteries, which constitute a very large proportion of the plant, are under entirely new conditions as regards their working and supervision, and, until experience shows what provision is necessary, a renewals fund will be maintained out of the profits, in order to make provision for exceptional outlay in any one year.

The Directors have to report the retirement of Lord Thurlow from the Board of the Company, and the election of Mr. Emile Garcke (Managing Director of the Brush Electrical Engineering Company, Limited), to fill the vacancy, subject to the confirmation of the shareholders. Mr. J. Irving Courtenay has been elected Chairman of the Company, and Major-General Webber, C.B., Deputy-Chairman while still retaining the post of Managing Director. The retiring Directors are Mr. J. Irving Courtenay and Sir George Prescott, Bart., who, being eligible, offer themselves for re-election. The Auditors, Messrs. Cooper Bros. and Co., also offer themselves for re-election.

Bedford Electric Light Company (Limited).

The annual meeting was held at the office of this Company, St. Paul's-square, on Saturday. Beyond the submission of the balance-sheet, which showed that £150 had been placed to deposit account at the London and County Bank, and that the total expenditure up to date amounted to £33. 14s. 5d. only, the business was purely formal. The retiring Director, Sir Henry Mance, was re-elected, and Mr. James Hull appointed auditor for the current year.

In discussing the position of the Company, the CHAIRMAN remarked that as promised at the previous meeting, they had been extremely careful not to spend a penny unnecessarily, and they would continue to follow this policy, so that if the Company did not eventually undertake the lighting of Bedford, the public would practically receive back their payments in full. In answer to a public invitation from the Corporation to tender for lighting a certain area in the town, the Company had submitted a proposal, which was still under consideration. He thought it would have been better to have commenced in the centre of the town and extend the area gradually. In his opinion, the Corporation had attempted too much, and tried to please everybody, and the question of public lighting was one distinct from private supply. The Corporation could please themselves as to lighting the streets; they might, at least, allow private individuals to use the light if they felt so disposed. With regard to the future, he thought that whether the Corporation did the work themselves or entrusted it to others, the electric light would assuredly be established in Bedford sooner or later. If the Corporation gave the work to other contractors, it would ultimately be necessary to work it by means of a company, and the organisation of the local company already formed would be useful to any parties who might come forward, supposing the overtures already made by the present management were not favourably received.

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The West India and Panama Telegraph Company (Limited).

The twenty-eighth ordinary general meeting of the members of this Company was held at Winchester House, Old Broad-street, on Wednesday, under the presidency of C. W. Earle, Esq.

The SECRETARY (Mr. R. T. Brown) having read the notice calling the meeting, the report of the Directors was taken as read.

The CHAIRMAN: Gentlemen, if you adopt the report, this meeting will constitute somewhat of an epoch in the financial history of our Company. It is a marked period, because we shall free ourselves, after this meeting, from the incubus of arrears upon our preference shares—an incubus which has been in existence since 1880. It will also be marked in this respect, that we shall pay for the first time since 1878 a dividend on our ordinary shares—a trifling one, but still a dividend, and the fourth which we shall have paid, in the 21 years of our existence, on these shares. I think I may be allowed to express my appreciation of the self-denial and patience of our shareholders who have borne so long with this unfortunate condition of things; and, perhaps, I may feel justified in taking some little credit to ourselves on this side of the table for having resisted the very numerous financial schemes pressed upon us from time to time, which, if they had been adopted, would have left us to-day in a very much worse position than we are in. Looking at our accounts we see that there is an increase in our gross revenue of £1,210, while the expenses have decreased by £5,175. The decrease in the expenses is almost entirely attributable to our not having had so many cable repairs to execute, and a consequent decrease in the expenditure on cables, and also a saving in expenditure on ships in coal and other matters which have to be incurred when the vessels have constantly to go to sea. The increase of £1,210 has been brought about by several small items. There has been an increase in the traffics of £1,608, but as a set-off against that there is a decrease in the subsidy accounts by our having received only £500 from the Colony of Martinique, against £1,000 in the corresponding period in the previous year. I shall have something further to say about this Martinique question later on. With regard to the traffic returns, it is impossible to conceal from ourselves the rather sad fact—indeed, the very sad fact—that there is no growth or progress in the telegraph returns of the West Indies. We see a very different state of things in the great, temperate-climate Colonies where there are lines of cables. In those Colonies there is progress and growth, and you see an increase in the commercial and industrial enterprise as a consequence. The West Indies are mostly circumscribed in extent, they are islands of limited size, and they are not new countries. It is probably known what can be got out of them, and there does not seem to be any indication of large industrial and commercial growth among them. In such a condition of things it appears to us quite clear that the use of telegraphy in the West Indies must always be restricted, and consequently also comparatively expensive. One would think in such a state of things that we should be free from what is the great bugbear of successful companies—competitive lines—but we are not. First, there is the occasional rumour of what they call the tactical line, some line to serve the purpose of the military department in time of war; and it is supposed that it will be free from all foreign interference. I believe that at the very moment when these tactical lines are wanted there would not be one of them—or, perhaps, a commercial line either—in the region where the military operations were of importance that would not be torn up in a war, and it seems to me most curious that where people have commercial lines they should give large subsidies to carry our tactical lines which would be very destructive to some of the commercial lines, and fail the Government at the very moment when they are wanted. Then we have another class of competitor, which we call the "National Susceptibilities" cable. Under that class I venture to put the French cable which has come into our region. I believe the French have a sort of sore feeling that the communications with their Colonies should all be carried by English enterprise; and they are taking what steps they can to correct that inferiority in their position, as they regard it. I think some of you may have observed lately an account in the papers of a gentleman who is connected with Canada, who is touring in the West Indies, and combining business with pleasure by suggesting to the various communities there that if he is only empowered by subscriptions he will be able to lay lines of cables that will serve all these Colonies—cables, of course, which would never be interrupted, and doing the work at one-fourth the rates which are now being paid. I have no doubt that this gentleman is having a very good time of it in the Colonies, because the liberality and hospitality of West Indians is proverbial, and when a gentleman can preach such a gospel as quarter rates and cables to be always in work there is no doubt that he will be very well received by our West Indian friends; but I think he must be endowed with very great faith in the gullibility of mankind if he thinks that, with the experience which we have gained in the 20 years we have worked the West Indian telegraph business, he can get people to subscribe money on anything like the basis of the advantages he holds forth to the communities. In regard to the Martinique subsidy, the position there has been several times fully explained, not only in the reports, but also by myself in this chair; and when we last met, it was a question whether we should take any legal process against the colony of Martinique for the treatment we had received from it in breaking off, under instructions from the Colonial Office in Paris, their engagement to us for a yearly subsidy. The sum in question was only £2,000, and after taking advice in Paris from a lawyer of eminence there, and fully considering the whole matter, we thought we had better put our pride in our pocket and receive £500—one quarter's subsidy—in settlement. We should have had to bring an action in the colony of Martinique which might have gone against us, and then we should have had to appeal to the Conseil d'Etat in Paris; and considering the expenses we must have incurred I think you will agree that we have acted wisely in accepting the position.

A SHAREHOLDER: May I interpose for a moment to ask if that £500 covers everything, or are there any expenses?

The CHAIRMAN: There are no expenses. Now we come to the laying of a new cable between Demerara and Trinidad. That, I think, has been put before you fully at former meetings and in former reports. I think it was in 1876 that we were able, by a very fortunate arrangement which happened to present itself at that time, to duplicate the greatest part of our system. We did that by an issue of ordinary shares at a figure which, compared with their present price, was very good; but the means at our disposal did not enable us to go so far as to connect the Island of Barbadoes and the colony of British Guiana, and they have been dependent on a single cable since the Company was started. We know from long experience that single cables are not very reliable means of communication, and it has been constantly urged on us by these two colonies, which are important, comparatively, in the way of traffic, that we should duplicate them. Formerly they were in the habit of voting their subsidies yearly. We replied to them, after a great deal of negotiation, "We will lay another cable to each colony if you will give us some fixity of tenure by agreeing to a subsidy for 10 years." The negotiations, especially with Demerara, dragged on for some time, but at last, as our report announces, they have been finally settled by giving us an extension of 10 years of their subsidy, and without alterations in the terms. We have already laid one cable—from St. Vincent to Barbadoes—and now we propose to lay the other to Demerara. When we had decided to lay these cables the question arose how to pay for them, and, after a great deal of consideration, and being convinced that extra lines of cable such as those we propose to lay should be a capital, and not a revenue, charge, we decided then to raise the money on capital account. There are two ways open in raising the money on capital account, one is by making a further issue of Second Preference Shares, and the other is the plan which we finally considered best—to issue debentures for the sum required. With respect to the plan of issuing Second Preference Shares, there would have been this very great disadvantage, that we should have had to pay 6 per cent. for the money; and also it would not have held the balance quite evenly between the liability for this money as among all classes of shareholders. Our First Preference shareholders would have had something more put behind them, which would have been nice for them; but seeing that it would have to be done at a large price, we thought it would not be fair to the Second Preference shareholders or the ordinary shareholders, and we propose, therefore, to issue debentures. With regard to the traffics, I daresay you may have observed a falling off in our receipts this year, but we are now comparing with one of the most successful sugar-growing years, and our traffics do go up and down with the state of the sugar industry in the colonies. We are comparing with, perhaps, one of the most successful years the colonies have had for a long time, and our receipts, though they do show this falling off, are about on a level with what they were in the year before. We have also fortunately been very clear from interruptions this year, and though we are not quite at the end of the half-year (having some seven weeks to run, and one never knows what may happen in seven weeks with cables), still, I think, there is every prospect of the current half-year being fairly satisfactory to the shareholders. I now propose the following resolution:

"*Resolved that the Directors' report and accounts to the 31st December, 1890, submitted to this meeting, be and the same are hereby received and adopted; and that, as recommended by the Board, a payment of 6s. per share on the First Preference shares, being dividend for six months to 31st December, 1890; 34s. 6d. per share on the Second Preference shares (i.e., 28s. 6d. balance of arrears and 6s. dividend for the six months to 31st December); 9d. per share on the Ordinary shares (free of income tax) be and the same is hereby declared.*"

Sir JAMES ANDERSON: I have much pleasure in seconding this resolution, and to save time I ought to express regret at the absence of Mr. Ford, who has seconded the adoption of the report every year since the present Board came into office. I regret his absence, because I think he would have done justice to the report, and would have referred to some points with the enthusiasm which belongs to him; and especially would he have drawn attention to the fact of the dividend which is proposed on the ordinary shares.

Mr. R. J. KING: I should like to make a few remarks, and perhaps on the score of years and seniority of time as a shareholder I might do so. I do most sincerely congratulate the Directors of this Company, to whom I feel deeply indebted for their skilful management of our affairs. They have shown that if you have to have a concern managed it must be managed by gentlemen who understand the business. I think that the Directors have shown that they do understand it. It was said some time ago that we had on our Board the cream of the practical Directors of telegraph Companies. I believe that; and I congratulate the shareholders upon the commencement, as I hope, of better days, the present taste of dividend, which is very pleasant, and which, I hope, is only an instalment of what we shall get in the future. I am able, I think, to tackle figures, and I say without hesitation that I think this is only an instalment of what we may expect in the future. If you look at the accounts you see that there has been a very considerable amount of arrears paid this half-year on the second Preference Shares. This wipes out these arrears, leaving nothing more to pay on that account, and if we took that amount from the credit of the ordinary shareholders, instead of the dividend being 9d. per share it would have been something considerably more; therefore I do hope and believe that we are now beginning to receive some slight advantage from our investment, which, as you have indicated, has been a most unprofitable one.

Sir GEORGE H. CHAMBERS: There are a few observations I should like to make. In the first place, I think I may congratulate our friends on the other side of the table upon their moderation, and I do so for two reasons. One is that moderation is not always to the front, but it will increase the confidence we have that these gentlemen do not lead us with sanguine expectations and then leave us afterwards in the chill of

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disappointment. Nevertheless, it is well just to glance at the figures, which I have gone over with some care, and I do so more particularly in consequence of your Chairman's observations with respect to the West Indies. I find that our average income in the last five years was £68,000 a year, after paying working expenses. The dividends upon our investment are now £6,000 a year, giving us £74,000. With respect to the Chairman's observations as to the state of affairs in the West Indies, and their telegraphing not having increased, as in other parts of the world, I think I must remind the meeting how seriously these colonies have been injured by the bounty system, and what a dreadful period of depression they have had to go through. Happily, they are recovering from these difficulties. What the Chairman said about the crop of last year is evidence of it. The present crop, through bad weather, is not likely to be so good, but there is no reason why next season's crop should not be as good as that of last year. Though up to the present we have not seen such growth in our traffic as we could wish, I think we have a fair prospect in that direction in the future. I would, however, rather dwell on the figures as they are. Out of our £74,000 a year we have spent on maintenance, which includes not only repairs but additions, £24,700; our Debenture interest is £2,500 a year, and our Preference dividend is £23,500, together £50,700, leaving us £23,300 a year only. That is about £3,000 short of a dividend of 3 per cent. on our ordinary shares. I thought it well to give you these figures. There is another point upon our investments; we have a profit of from £12,000 to £14,000. I should not be at all prepared to recommend that the profit should go to increase the dividend, but rather that it should strengthen the capital. But seeing that the reserve fund stands now nearly at £146,000, and that virtually, looking at its improved value, it is a long way over £150,000, I think the time has come when it should be a matter for consideration whether or not we should apply the dividends on these investments towards the payment of dividends. I rather regret that it was not done in the present instance, because that would have given us a dividend of 1s. 6d. a share, and have still left us with a balance, notwithstanding that the prospect is, as has been stated by the hon. proprietor here, better for a larger dividend even than that in the future. Nevertheless, I so fully concur in the congratulations offered to us by the change in our circumstances, that I not only make that remark, but I do not propose any alteration in what the Directors suggest.

The CHAIRMAN: Gentlemen, I beg to thank you for the flattering remarks which have been addressed to us by Mr. King in the first instance and afterwards by my friend Sir George Chambers. It is true that we do not see Mr. King here sufficiently often, and this is the first time for a great many years that we have had the pleasure of seeing him at our meetings. I am very thankful to him for the kind way he expressed himself about us. As to Sir George Chambers' views, being so encouraging they are of very great value, because no man knows more about the West Indies, their trade and position than Sir George Chambers; and when he speaks so hopefully and in such an encouraging way of our field of enterprise, I think that we all feel a little comfort. The suggestion he has made about the reserve fund causes me some little difficulty, because our reserve fund is calculated upon three factors—the life of a cable, the price of a cable, and the amount of interest we get upon our investments. If we were to stop interest accruing to the reserve fund, then that fund would remain where it is, but the depreciation of our cables is going on every year, and we have taken a very long life for a cable—30 years—as the basis. It is, however, incumbent on us to set aside in one way or another, either in new cable or renewals, or in interest on the reserve fund, such a sum as will keep level with the depreciation that is going on. It is for that reason that in the present half-year we find that our calculated reserve fund is what it ought to be up to the date at which the accounts close—the 31st of December last year; and therefore we are not under any necessity of adding to it. It is added to itself practically by the new cable put in during the year, which goes into the account, and also by some £2,800, the interest upon the half-year. These accumulations have gone to the reserve fund, and have obviated the necessity of making any direct contribution to it. I think that it is essential to keep the reserve fund up to the proper amount to represent the depreciation that is going on year by year in our cable. The cables have been down a good long time now—20 years—and though it may seem a large sum that we have at the credit of the reserve fund, if you think that we have over 4,000 miles of cable, and what it would cost to have any extensive renewal of the lines, I believe you will see that a reserve fund of £150,000 is not an extravagant figure.

Mr. TREBLE: May I ask if the increase of the debentures will involve an increase of £2,500 a-year in the charges?

The CHAIRMAN: It depends on what we can issue them at. It will involve an increase, of course. He then put the motion, and it was carried unanimously. Continuing, he said: I now propose the resolution with respect to the debentures as follows:—

"*Resolved:—1. That the Board be and are hereby authorised to borrow and raise from time to time such moneys, not exceeding in the whole* £100,000, *as they may think necessary for any of the purposes of the Company, including the payment off and extinguishment of the existing* £50,000 *Debenture debt falling due on December 31, 1891.*

"*2. That the Board be and are hereby authorised to raise the said* £100,000, *or any part thereof, at such times, at such rate of interest, and on such security, terms, and conditions in all respects as they may think proper, and also from time to time to execute and issue Debentures and other securities or obligations of the Company in respect of such moneys.*"

I think the report clearly states what are the limits and purpose of this demand upon you with respect to the increased power asked for in regard to an increase in the debenture debt. It is quite clear that £100,000 is the limit of the power we ask you for, and £50,000 of that will replace the debentures now extant, and the other £50,000 will go to pay for the new cables which will add so much strength and permanence to your system.

Mr. W. S. ANDREWS: I beg to second the resolution.

Mr. COPP: Before you put that, may I ask a question? I perceive that in consideration of laying these cables you get a subsidy of £4,500 a year from one of the Colonies. Is that in excess of the previous sum, or the same?

The CHAIRMAN: The same. We spend this money without any further subsidy or any other advantage except the extended time.

Mr. COPP: It will be permanently an extra charge?

The CHAIRMAN: Yes; but there will be an economy in connection with this expenditure. When these cables are interrupted, and being single cables that happens pretty often, the Colonies stop the subsidy, ships have to be put on to carry the messages, and the repairs have to be done very quickly. We have to take the ships from wherever they are, and to press on with the work of repairs as quickly as possible. All this means considerable expense, and this outlay is, therefore, not all pure outgoing.

Mr. COPP: There is another point I should like to refer to. With respect to the reserve fund, it has occurred to me that it might be a profitable investment to invest the fund in our own debentures. We have a lot of investments which can be sold to pay 3½ per cent. Is there any reason why the money should be kept in these securities instead of putting it in our debentures, and so saving, perhaps, £1,000 a year? It strikesme that there might be a considerable saving by that means.

The CHAIRMAN: No doubt, from a mere financial point of view, that sounds, and is, very good finance; but one of the great objects of a reserve fund is to have something that you can realise in a moment of difficulty. Suppose, for instance, a serious break occurred in the two long cables that go from Jamaica to Porto Rico, and it was found that the repair would take a long time to effect and cost a great deal of money, we should then have to go into the market, and we could not do so with the same advantage if our reserve fund was invested in our own debentures as we could go now.

Mr. COPP: I do not propose that you should use all the reserve fund for investment in our debentures—say, £50,000.

The CHAIRMAN: Well, £100,000 would not go a long way in repairing a cable like this. I think we had better keep our reserve fund in convertible securities.

Mr. KING: I hope you will not touch the reserve fund by one farthing, for by doing so you would diminish our security. You want something that you can realise at a moment's notice if you require the money. If you were to invest our reserve in our own bonds it is a mere levelling down into the whole mass, and is lost as far as your power goes to use it.

The CHAIRMAN put the motion, and it was carried unanimously.

Mr. C. W. Earle and Mr. W. Ford were then re-elected as Directors, and Mr. J. G. Griffiths as auditor, and a unanimous vote of thanks to the Chairman brought the meeting to a close.

The Western and Brazilian Telegraph Company (Limited).

The twenty first ordinary general meeting of this Company was held on May 8th, 1891, at Winchester House, Old Broad-street, London, under the presidency of W. S. Andrews, Esq.

The SECRETARY (Mr. R. M. Cunningham) read the notice convening the meeting, and afterwards the minutes of the twentieth ordinary meeting, which were approved by the present meeting, and signed as correct by the Chairman. The report and accounts were taken as read.

The CHAIRMAN: It is again my pleasing duty to report to you that the receipts are once more of a satisfactory character. They have amounted for the past half-year, to the 31st of December last, to £108,817. 10s. 5d., as compared with, in the corresponding period of the previous year, £86,403. 0s. 7d., showing an increase of £22,414. 9s. 10d. Well, of course, that is a very gratifying state of things. We cannot particularly ascribe it to any one cause, but as far as we can trace cause and effect, no doubt, the large speculation that there has been, the excellent crops that have been talked about, the excitement in the countries concerned, and the political difficulties of the time, have all combined to assist in producing the result which we have reached. As regards the expenses, they amounted for the same period to £37,200. 2s. 4d., and they compare with £40,391. 11s. 9d., so that there is a reduction in the expenses of £3,191. 9s. 5d. Now, these two antagonistic things will no doubt be satisfactory to the shareholders, because they take place in those respective departments of the accounts which by this comparison end in giving the shareholders more money. In analysing Abstract A, which is that relating to the expenses at the stations abroad, where the money is earned, we find that there are seven items of increase and six items of decrease, and that there is one item that has not appeared before in the accounts—namely, that for establishing duplex apparatus at the stations. Omitting the duplex—which, of course, is not an annual charge, and does not come properly into this expenditure, and will not occur in this particular case again, the expenses show an increase of £1,298. 19s. 2d. Well, of that total £1,198. 18s. 8d. are the expenses of working these stations. Tho e represent the main cost indeed of earning the revenue, and are occasioned by mechanical increases under old agreements; promotions in the junior staff, which is always getting older, like most of us, and becoming senior staff instead of junior staff; and a good deal more work. The remaining increases and decreases under that head practically balance one another. They are all small, and it is not necessary to labour this, because it will not give you any information that is of any use. I will now take Abstract C, because that rather belongs to the same question of expenses, that is, the expenses in London. The expenses under this abstract for the half-year were £2,961. 12s. 2d. compared with £2,710. 8s. 5d., so there is a small increase there of

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£251. 3s. 9d. That is spread over five items. There has been a good deal more work to do, and a bonus was given at Christmas to some of the junior clerks. Now, gentlemen, you see there is that increased expenditure in the commercial staff, the whole of which comes to a sum of about £1,400, and you will be glad to know, probably, what additional work has been done for this not very considerable sum of money. The additional work done, you will perhaps be rather surprised to hear, amounted to 31 per cent., so that that is an outcome which, I think, you must all agree is exceedingly satisfactory. Next I will deal with Abstract B. It is under this abstract that the real saving of the year has been made, and it is owing to the fact that in the half-year under review there was no ship under charter. You will remember that at the corresponding period in 1889 we had a ship under charter, and that consequently our expenses under the head of shipping were considerably increased. There is, of course, an increase in our own shipping expenses of £3,508. 16s. 6d., because our ships had to do all the work. The "Norseman" was very busily employed; the "Viking" was not so busily employed, and there was a small saving on the "Viking." The great feature, however, remains that the chartered ships item, amounting to £8,531. 1s. 3d., is entirely removed from the account, and the consequence of that is a reduction under shipping of £5,434. 8s. 10d. It is satisfactory, too, that this reduction would have been greater had the ships been fortunate enough in the past half-year, as they were in the corresponding period of the previous year, to get some charters, because we had two charters in that half-year, and we received under that head £1,762, which went against the expenses. We have not been so fortunate this half-year, but still we have done well. The cable used cost us £234 less; but the depreciation in ships has been £229 more. Well, the net result of all this is not bad. The revenue we have earned is £22,414 more, and the money that has been spent to earn it £3,191 less. The gross receipts for the half-year were £108,817. 10s. 5d., and the gross expenses were £37,200. 2s. 4d., so that there is left £71,617. 8s. 1d. Adding the amount brought over from the preceding half year, £5,751. 7s., and the dividend on the Platino shares, £9,233. 10s., you get at the gross amount which you have to deal with—£86,602. 5s. 1d. Then you calculate interest on the debentures, £13,164; the amount placed to debenture redemption fund, £5,936, and the similar sum put to the reserve of £20,000. These three items amount to £39,100, and there is a sum left of £47,502. 5s. 1d. We recommend you to declare a dividend of 9s. a share, making up 5 per cent. for the year. That will take £41,431. 19s., and it will leave £6,070. 6s. 1d. to carry forward to the current year. That, gentlemen, concludes our dealing with the figures. You will remember that at our last meeting we reported that, after very considerable delay and very great trouble, we had succeeded in obtaining from the Government their consent to our laying certain loop cables for the purpose of strengthening and improving the system. One of these loops has been already laid between Monte Video and Chili, and it appears in the Company's accounts. The next sections are, I believe, made, and will go out very shortly. They extend from Pernambuco to Bahia, from Bahia to Rio, and from Rio to Santos; and they cover the chief portion of that part of the system south of Pernambuco where our revenues are mainly earned. We believe that these loops will be sent out and be laid by about June, and when they are laid, of course, your property over the district which they cover will be more secure than it has ever been before, and, of course, it is likely to remain, as far as one can see, uninterrupted. Well, there was one rather unpleasant feature in connection with this business—that is, that while all these negotiations were going on, the price of cables was rising. Gutta percha was becoming dearer, companies were having to pay more for labour, and so on. However, the course adopted by the Company was, no doubt, one you will approve—that of proceeding by tender, by which means the best prices that could be got were got, and the lowest price was accepted—the tender of the India Rubber, Gutta Percha, and Telegraph Works Company—and we know that from them we shall get a thoroughly trustworthy line of cable. The ordering of cables may be pleasant enough, but there is another consequence that follows, they have to be paid for; and the question with us was: How are we going to pay for these cables? We have no capital, as you are aware, and there are no means of issuing capital. Our debenture arrangements are such that we could not issue debentures to the public, and, after citing no end of means by which it could be done it really seems as if there were only one way of doing it—that is, to pay for these cables—for the present, at all events—out of the reserve fund. Owing to the increase in price, there is some £185,000 to be provided. This, of course, is a pretty heavy draft on the reserve fund, but we propose to strengthen that fund by issuing the £50,000 of debentures which we still have power to issue, but which we shall not offer to the public. We propose to issue them at 4 per cent. only. We have our reasons for that. We should place this issue in the reserve as a payment back by capital to revenue for money originally taken from revenue, and we should issue them upon terms which would enable us to recall them, so that we should not interfere with any big measure we may be enabled ultimately to carry with respect to the debentures generally. Well, we have to sell investments to produce the money. We have made our calculations, and we find that on the sale of the stocks which we have selected for the purpose we shall secure a profit of £11,000. That is a satisfactory fact, and of course it goes in reduction of price really, because it is a something that has been created out of nothing—an unearned increment. Counting £50,000 of debentures and this profit the reserve will still remain, I am pleased to say, at a very respectable figure, namely, just upon £100,000, actually about £99,000; and the additional charge for these new lines will be very small. Altogether, what with the arrangements we made some years ago to devote £26,000 to paying off discount on previous issues of debentures, and what with the liberal policy, I will call it, of the shareholders—at the same time, I think the wise and discreet policy of the shareholders—we are enabled to carry out this great work—for it is a great work—for the improvement of your property entirely out of the savings of the concern. Your reserve is so strong that you are able to draw upon it for this very considerable addition to your system. It is a satisfactory circumstance, that the bed of the ocean where these cables are going to be laid is one suited to our purpose. It is too deep for anchorage, and it has about as good a bottom as we could possibly have to put our property on. This measure ought, of course, to give increased security to our trade. It will diminish interruptions, it will make us stronger, and certainly preserve, if not improve, our revenue, because, although, I am pleased to say, the service is efficient now, and our officers deserve credit for it, yet I think we may improve it notwithstanding. We are none of us perfect, and if we have additional means of making our service even more efficient than it is, no doubt our officers will know how to make use of them. The question has been very often in the minds of the proprietors: What are we to do with the debentures? This has been a sort of "old man of the sea." It has never been off our shoulders. If there has been one, I should think there have been half-a-dozen schemes for dealing with this question. We have taken all sorts of advice, consulted all sorts of people, and we began almost to despair of devising something which would conciliate all interests, especially the legal interest. However, in the end we are told by great legal luminaries that we have surmounted the difficulty, and that we have got a scheme which will avoid all the legal pitfalls, which is as simple a scheme as can be expected under the circumstances—that is the highest praise I can give it—and that consequently we may congratulate ourselves upon having a something now which can be carried out from the legal point of view. But, of course, there is something over and above the legal point of view. We have no compulsory powers with the debenture holders, and we must, therefore, convince them that their position is in no way prejudiced, but rather improved, by this scheme. We must conciliate them as permanent investors. We have only within the last 30 hours got the final legal opinion, and, therefore, we have not been able, as we should otherwise have done, to consult some of the larger debenture holders. We shall, however, consult them, and we shall see whether, as a commercial as well as a legal business, we can make our scheme go. If we receive encouragement from our debenture-holders we shall try it. We did not think it worth while to come before you with any proposal, because the thing, though ripe in a sense, is not quite ripe enough. When we have received opinions which we can rely upon it may be that we shall call you together to consider this matter, which is very important, largely concerning your future interest, and one which will, I think, if favourably resolved, considerably improve the *status* of your property. When we last met there was another thing hanging heavily on our minds—namely, the question of the competition of the various lines projected at that time. There was an Argentine line, but that seems to have dropped. There was another line to the North—to the United States, which also seemed to have dropped, but this has been revived. The Paris Telephone Company appears to have so much money since its purchase by the State that it does not quite know what to do with it. So it has taken up this line to the United States of America. A section has been laid from Martinique down to Parmarhibo, in French Guiana, and the expedition is going out, or has gone—(A voice: Gone)—to extend from Parmarhibo to Vizeu, in Brazil. Then I believe the expedition goes North and lays a length of cable from Guadeloupe to Puerto Plata, and the idea is that the scheme should ultimately be extended to America. We do not know whether it will be or not. We have always felt that under our concessions in Brazil we had certain rights in the more commercial provinces which would safeguard us to a great extent from the effects of competition; but however that may be—whether we have that protection or not—I am sure that all of us will be of opinion that "threatened men live long." We have been threatened for many years, and are still alive, and pretty prosperous; and I am not quite so sure, looking at the elasticity of the traffic, looking at the fact that the Western and Brazilian and the Brazilian Submarine Companies have the direct route—you see from this map that it is almost a straight line from Europe and the United Kingdom to these places, whereas the other people go all round the western world to get there—I think, looking at that fact, and that the Brazilian Submarine Company has entirely duplicated its system, and that our system will very shortly be duplicated over all the busy parts—I say that, looking at all these matters, we may not have to fear these lines so very much. We may be enabled—and I hope we shall—to hold our own. We are experienced in the work; our men are all up to their business. The work is well done and quickly done, and I doubt whether these other lines will find that it is quite so easy as they may think at the present time to make considerable deductions out of our revenues and put them into their own pockets. I think we shall have something to say to it, and I think, at all events, that we shall do our very best, as I hope we have always done, to keep your traffic together, and to continue, as far as lies in our power, the present current of your prosperity. I daresay, gentlemen, you have noticed another thing, namely, what I should call the abnormal traffics of this current period. The traffics, you know, have been immense, and I do not want you to go away and think that in what I have said I have been referring to the preservation of these traffics. I am not. I am only speaking of the normal traffic. These present large sums that you see figuring every week in the papers are caused by the fact that Chili is in a state of difficulty. The telegraphs are all stopped, including the line at Valparaiso, which competes with our system. These lines cannot take any traffic from Buenos Ayres and Monte Video, and send it round by Chili, and therefore we get practically all this traffic. You must therefore be prepared, without the slightest feeling of discouragement, for a reduction of traffic at the end of this war business in Chili, and you will get to your normal revenues; and I do hope, as they have been fairly satisfactory for a long time past, to keep them. We shall do our best. When these East Coast lines get through we shall lose a large part of the abnormal business, but still some of it will cling. There is a sort of inclination on the part of people to stay when there has been a long interruption like this. I do not know that I have anything more to say, and therefore I will conclude by moving—

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"*That the report and accounts to the 31st December, 1890, be hereby approved and adopted, and that a dividend of 9s. per share, free of income-tax, making, with the interim dividend paid in November last, 5 per cent. for the year 1890, be, and is hereby declared, payable on the 13th inst.*"

Mr. H. WEAVER: I beg to second that.

The CHAIRMAN: Before putting this resolution to the meeting, I shall be very happy to reply to any question that any shareholder may like to ask.

Mr. PETO congratulated the Directors on the successful report which they had issued, it being a most satisfactory feature that, while there had been an increase in the receipts, the expenditure showed a diminution. He had recommended many to invest in the Company, and he was pleased to say that in all cases his friends had doubled their capital.

Mr. CLARK asked whether the difference between the amount of the investment and the sum under the head of reserve fund was in cash in hand; and whether the "Norseman" was engaged in laying the new lines. Was it intended to work with one ship?

Mr. JACKSON thought all the shareholders must feel satisfied with the report and the Chairman's statement; and he thought the Chairman had acted rightly in pointing out distinctly that the present traffic was exceptional, due to the disturbances in Chili. It appeared to him that their position was most sound and satisfactory, especially as there was to be no call for fresh capital in this most stringent time, when such an absence of confidence existed.

Mr. ENNIS also said he thought the report and accounts might be issued with less delay than at present.

Mr. COPP inquired whether the ordinary shareholders would have an opportunity of tendering for the £50,000 of debentures which were to be issued.

The CHAIRMAN: It is not proposed to issue the £50,000 of debentures to the public. The money will be put into the reserve fund really, for the purpose of strengthening it, in view of the considerable sum which we are taking out of it, and we are not issuing it to the public because of the more extensive arrangements with respect to the debentures to which I have referred.

Mr. HUBBARD: In the last balance-sheet I see the words "reserve fund" instead of "renewal fund." Is that a clerical error or intentional?

The CHAIRMAN: It is intentional. Reserve, as a fact, is not confined to the one thing which the word "renewals" implies. With respect to the reserve fund, an honourable proprietor drew attention to the fact that there is a certain difference between the amount under the head of investments and the total amount under reserve fund. The difference between the two exists in cable and ships. A portion of the reserve funds, in other words, had to be invested in spare cable and ships, because, as I have previously mentioned, we have been deficient in capital. Another question was asked as to whether the Company, in view of the increased safety of its system, would work the system with one ship. That is a question which at present, with every deference to the honorable proprietor, I am not in a position to answer. The next very proper question put by Mr. Jackson is as to this four months' delay, as he says, in getting the accounts over. It seems a very simple thing to get accounts over when you come to calculate the number of days taken and that sort of thing, but we have 13 stations in all parts of Uruguay. These stations are situated—some of them—in rather awkward places, and, as a fact, it takes a very long time to get the information into the office, to get it checked at the office, and to have the requisite control over the expenditure, and so on, locally. All these things have to be returned to and fro; otherwise you would get everything accepted, and your expenses would be considerably increased. A check, however, must be kept, and these things have to go backwards and forwards. Then they are sent over here to work out. We have also to exchange accounts with our partners. On the whole, I can assure you that we present these accounts as soon as we possibly can. By-the-bye, I did not explain what has just been pointed out to me by the Secretary—that we cannot hold our meeting until the Platino Company hold theirs, because we must get their dividend paid to us; and they must hold their meeting, under their Articles of Association, in May. I do not think there are any further questions remaining to be answered.

Mr. CLARK: I asked whether the "Norseman" has been laying the new cables?

The CHAIRMAN: Oh, no, that is a large expedition. You want a ship of 5,000 tons for the purpose.

Mr. CLARK: But what is the reason for the expenses being so heavy in connection with the ships?

The CHAIRMAN: Ships must and do cost a large amount per annum, breaks or no breaks, because they must be on the spot. You find that if they are very much in port the expenses are very much less, because of the coal which is used when they are much employed in steaming. He then put the motion in the usual way, and, having declared it unanimously carried, vacated the chair pending his re-election.

Mr. W. S. Andrews and Lord Richard H. Browne were then re-elected as Directors, and Mr. John Weise and Mr. J. G. Griffiths as auditors, and, after a cordial vote of thanks to the Chairman, the meeting separated.

NEW COMPANIES REGISTERED.

BOY MESSENGERS AND ELECTRIC CALL COMPANY (LIMITED).—Registered by P. B. Ryan, 11, The Members' Mansions, Victoria-street, with a capital of £200,000 in £1 shares. Object: to acquire the business of the Boy Messengers, Limited, and to work the messenger and electric call system in London and elsewhere, within a radius of five miles from the General Post Office. There shall not be less than three nor more than twelve Directors. The first are Captain W. H. Davies, Lord Frederick Hamilton, Sir Frederick Milner, Bart., M.P., the Hon. P. B. Lyon, and R. King. Qualification, £100. Remuneration, £2,500, divisible.

CITY OF BATH ELECTRIC LIGHTING AND ENGINEERING COMPANY (LIMITED).—Registered by Kingsford, Dorman, and Co., 23, Essex-street, Strand, W.C., with a capital of £60,000, in 5,500 ordinary £10 shares and 50 £10 founders' shares. Object: to adopt and carry into effect an agreement made May 2 between Henry George Massingham of the one part, and the City of Bath Electric Lighting and Engineering Company (Limited), of the other part, and to carry on generally the business of an electric light and power company. The first subscribers are:—

	Shares.
T. Vaughton, 7, Cavendish-place, Bath	50
J. G. Jervois, 16, Lansdowne-place East, Bath	50
A. Pitman, 12, Royal-crescent, Bath	50
E. B. Titley, 15, Orange-grove, Bath	50
H. N. Garrett, 101, Sydney-place, Bath	50
E. Pitman, 12, Royal-crescent, Bath	50
W. Jeffery, 2, Northumberland-buildings, Bath	10

There shall be not less than five Directors. The first are Lieut.-Colonel Theo. Vaughton, H. N. Garrett, A. Pitman, Major-General J. G. Jervois, and H. G. Massingham, all of Bath. Qualification: 50 ordinary or five founders' shares. After payment of a 6 per cent. dividend upon the ordinary and founders' shares, the remuneration of the Directors shall be £500, divisible; failing the payment of such dividend, the sum of £250, divisible. Such sum of £500 shall be increased as soon as the actual paid-up capital, exclusive of founders' shares, exceeds £50,000, by a further sum of £50 for every £10,000 of additional share capital actually paid up.

EUROPEAN SIMS-EDISON ELECTRICAL TORPEDO COMPANY (LIMITED).—Registered by J. Andrew, 15, Marriott-road, N., with a capital of £201,000, in 10,000 ordinary £20 shares, and 1,000 £1 Founders' shares. Object: To acquire certain patents relating to torpedoes, and to carry on the business of an electrical company in all its branches, in Great Britain and any part of the world. The first subscribers are:—

	Shares.
E. H. Edwards, 30, Pellerin-road, Stoke Newington, N.	1
E. Sorrell, Oak Cottage, Fowler-road, Forest Gate, E.	1
J. Andrew, 15, Marriot-road, Tollington-park, N.	1
A. M. G. Carter, 40, Denning-road, Hampstead, N.W.	1
R. H. Ibotson, 37, Chatham-road, Wandsworth-common, S.W.	1
W. Brown, 121, Hungerford-road, N.	1
S. Woodham, 82, Evelina-road, S.E.	1

There shall not be less than three nor more than 12 Directors; the first are the signatories to the memorandum of association. Qualification, being a shareholder. Remuneration to be determined in general meeting.

ROPER'S ELECTRICAL ENGINEERING COMPANY (LIMITED).—Registered by J. M. Urquhart, 10, Denbigh-street, Warwick-square, S.W., with a capital of £15,000 in £1 shares. Object: to acquire the business of Roper's Electrical Engineering Company (late John and William Roper), electrical engineers, Trafalgar Works, Trafalgar-street, Bradford, Yorkshire, and to carry on and extend the same. Registered without articles of association.

CITY NOTES, &c.

BOY MESSENGERS AND ELECTRIC CALL COMPANY (LIMITED).—The prospectus of this Company, formed for the purpose of acquiring and extending the business of the Boy Messengers (Limited), was issued last week. The total capital of the Company is £200,000 in £1 shares, and the first issue was for 80,000 shares, the subscription list opening on Friday and closing on Monday. The prospectus states that after protracted negotiations the Company have obtained from the Postmaster-General the promise of a licence to work the electric call system. Amongst the Directors is Captain W. H. Davies, the managing director of the Exchange Telegraph Company (Limited), and the secretary is Mr. J. L. Burn, with offices at Billiter House, Billiter-street, E.C.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the past week amounted to £4,981.

CITY AND SOUTH LONDON RAILWAY COMPANY.—The traffic receipts of this Company for the past week amounted to £695.

GREENWOOD AND BATLEY (LIMITED).—The Stock Exchange Committee have ordered the undermentioned securities of this Company to be quoted in the official list:—Vendors' preference shares, Nos. 1 to 2,666; further issue of 2,600 ordinary shares, Nos. 14,001 to 76,800; further issue of 1,600 preference shares, Nos. 8,001 to 9,600.

RUSTON, PROCTOR AND CO. (LIMITED).—Notice is given that the transfer books of this Company will be closed from May 8th to May 26th.

ST. JAMES'S AND PALL MALL ELECTRIC LIGHT COMPANY (LIMITED).—Application has been made to the Stock Exchange Committee to appoint a special settling day in, and to grant a quotation to, this Company's ordinary and preference shares.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended May 8, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,964.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, May 6.		Price Wednesday, May 13.		Rate per Cent. Yielded	Dividend Due.	Business Done During Week Ending May 13.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS.								
£1,381,380	Stock	12/0	Anglo-American	47 48		47 48		5 19 9	Jan., Apr., July, Oct	47½	..
£2,809,310	Stock	21/0	Do. Preferred	85 86		85 86		6 13 9	" "	86½	86½
£2,809,310	Stock	..	Do. Deferred	12 12½		12 12½		..	.. ..	12½	12½
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99 102		99 102		3 18 5	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	11½ 12		11¾ 12½		6 2 5	Mar., June, Oct., Dec.	12	11¹⁵⁄₁₆
£84,500	£100	5%	Do. 5 per Cent. Bonds	101 104		101 104		4 16 2	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	104 108		104 108		4 12 7	June and December	..	..
$7,216,000	$100	7%	Commercial Cable Capital Stock	108 110		108 110		6 7 3	April and October ..	109½	..
16,000	10	8/0	Cuba Submarine	10½ 11½		10½ 11½		6 19 2	February and August	..	..
6,000	10	10%	Do. Preference 10%	16½ 17½		16½ 17½		5 14 3	" "	17	..
12,931	5	3 1/23	Direct Spanish (£4 paid)	3¾ 4¼		3¾ 4¼		6 11 9	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9 10		9 10		5 0 0	.. ..	..	..
60,710	20	3/6	Direct United States	10¼ 10⅝		10¼ 10⅝		6 13 4	Jan., Apr., July, Oct	10⅝	10½
400,000	10	2/6	Eastern	14⅜ 14⅝		14⅜ 14⅝		4 8 10	" "	14⅝	14⅜
70,000	10	6%	Do. 6 per Cent. Preference	15½ 15⅝		15½ 15⅝		3 16 2	" "	15⅝	15⅝
£1,200,000	Stock	6%	Do. 4 per Cent. Mort. Debenture Stock	106 109		106 109		3 13 5	May and November	107⅜	107⅛
£100,000	100	5%	Do. 5 per Cent. Debentures, 1899	107 110		107 110		4 10 11	February & August	..	..
250,000	10	0/6	Eastern Extension	14¾ 15¼		14¾ 15¼		4 13 4	Jan., Apr., July, Oct.	15¼	14¼
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock	105 108		105 108		3 14 1	.. ..	108½	106½
£91,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103 106		103 106		4 14 4	January and July ..	104	..
£145,300	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	103 106		103 106		4 14 4	" "	..	..
180,227	10	2/6	Globe Telegraph and Trust	9½ 9¾		9½ 9¾		5 7 10	Jan., Apr., July, Oct.	9¾	9⅝
180,042	10	6/	Do. 6 per Cent. Preference	14½ 15½		14½ 15½		3 19 4	" "	15⅛	14⅝
150,000	10	7,2	Great Northern	18 18⅛		18¼ 18⅜		4 10 8	Jan., April, and July	18⅛	18⅛
£15,000	100	5%	Do. 5 per Cent. Debentures, 1881	.. ..		.. ..		..	January and July ..	..	..
£480,000	100	5%	Do. 5 per Cent. Debentures, 1883	105 108		105 108		4 12 7	March & September	..	..
17,000	25	12/6	Indo-European xd and Bonus	42 44		39 41		4 11 6	May and November	..	..
38,348	10	4 0	London Platino-Brazilian xd	7 8		6½ 7½		6 0 0	.. ..	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106 109		106 109		5 10 1	March & September	..	..
9,000	8	4/0	Reuter's xd	8⅜ 9½		8 8½		4 14 1	April and October..	..	..
3,881	£100 Cert.	6%	Submarine Cables Trust 6%	116 121		116 121		4 19 2	.. ..	..	..
15,609	10	4/0	West African Telegraph	8 9		8 9		5 11 1	January and July ..	8⅝	..
£200,900	100	5%	Do. 5 per Cent. Debentures	98 101		97 100		5 0 0	March & September	99½	97
30,000	10	3/0	West Coast of America	3 4		3½ 4½		..	January and July ..	4½	3⅝
£150,000	100	8%	Do. Debentures 8% 1902	97 101		97 102		..	June and December	..	..
88,321	10	9d.	West India and Panama	3½ 3¾		3½ 3⅝		..	.. ..	3⅞	3⅞
34,563	10	6/0	Do. 1st Preference 6%	11¾ 12½		11¾ 12½		4 18 0	May and November	12⅝	..
4,669	10	£3	Do. 6 p. c. 2nd Pref.	11⅛ 12⅜		11⅛ 12⅜		4 16 0	" "	..	..
64,174	15	6/0	Western and Brazilian xd	12⅜ 13		11¾ 11¾		6 7 10	" "	12⅛	11⅜
27,873	7½	6/0	Do. 5 per Cent. Cumulative Preferred xd	6¾ 7½		6¾ 7		5 7 3	—	6¾	..
27,873	7½	4/6	Do. 5 per Cent. Deferred xd	5½ 6		4¾ 5¼		..	..	5¾	5¼
£200,000	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103 106		103 106		5 13 2	February & August	..	..
£250,000	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103 106		103 106		5 13 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage xd	117 122		117 122		5 14 9	May and November	..	..
£175,100	£100	6%	Do, 6 per Cent. Sterling Bonds	100 104		100 104		5 15 5	March & September	..	..
			TELEPHONES.								
224,850	14/0	0/4½	Consolidated Telephone Const. & Maintenance.	1/16 1/8		1/16 1/8		7 9 4	May and November	..	..
220,000	£1	4/6	Oriental (11s. paid) xd	¼ ⅜		¼ ⅜		5 2 11	Yearly	..	..
499,984	5	2/6	National	4¼ 4½		4¼ 4½		6 2 3	June and December	4½	4½
15,000	10	6/0	Do. 6 per Cent. Cumulative 1st Pref.	13 13½		12⅝ 13½		4 10 11	" "	12⅝	..
15,000	10	4/9⅜	Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd)	12 12⅜		12 12⅜		3 16 10	" "	..	..
..	£100	..	Do. Debenture Stk. 4½% Prov. Cert. (fully pd)	102 104		102 104		4 6 7	.. ..	103⅜	103
209,750	1	..	South of England, Ordinary	.. ..		.. ..		..	—	..	..
20,000	5	..	Do. 6 per Cent. Cumulative Pf. (£3 10s. pd)	.. ..		.. ..		..	..	..	..
58,000	5	1/0	United River Plate	2½ 3½		2½ 3½		..	January and July ..	..	..
£146,123	Stock	5%	Do. 5 per Cent. Debenture Stock	85 95		85 95		5 5 3	..	..	..
£3,200	100	..	Do. 7 per Cent. Debentures	.. ..		.. ..		..	—	..	..
			ELECTRICITY SUPPLY COMPANIES.								
1,000	£50	..	City of London Electric Lighting Shares (£25 pd)	32 34		32 34		..	..	..	..
19,970	£5	..	Electricity Supply Co. of Spain	4½ 5		4½ 5		..	..	..	..
5,922	£5	3½%	House to House Electric	4¾ 5⅛		4¾ 5⅛		..	..	..	..
30,000	£5	..	Liverpool Electric Supply (£3 paid)	2⅝ 2⅞		2⅝ 2⅞		3 13 1	..	..	..
111,000	5	..	London Electric Supply	2⅛ 2⅜		2⅛ 2⅜		..	..	..	..
43,900	10/0	2/0	Metropolitan Electric Supply (£9 paid)	9 9½		9 9½		4 5 4	..	9½	9½
7,730	£5	..	St. James' and Pall Mall	5⅞ 6⅛		5⅞ 6⅛		—	..	..	..
..	..	..	Do. 7% Preference	⅜ ½	prem.	⅜ ½		..	..	..	..
42,853	5	..	Westminster Electric Supply (£5 paid)	4⅞ 5⅛		4⅞ 5⅛		..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
68,416	2	..	Brush Electrical Engineering	2⅜ 2⅝		2⅛ 2⅜		..	..	2⅛	2⅛
68,416	2	1/1	Do. 6 per Cent. Preference	1⅜ 1⅝		1⅜ 1⅝		6 8 0	June and December	1⅝	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	4 5		4 5		7 0 0	January and July ..	..	..
17,180	5	..	Edison and Swan United	.. ..		.. ..		..	—	..	..
45,000	10	6%	Electric Construction	5 6		5 6		..	—	..	..
70,000	2	10/0	Elmore's Patent Copper Depositing	2¼ 2⅞		1¼ 2		..	—	2	1⅜
20,000	5	..	Fowler-Waring Cables (£4 paid)	2⅜ 3⅛		2⅜ 3⅛		..	—	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	18½ 19⅜		18½ 19⅜		5 2 7	February & August	19⅜	19
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104		102 104		4 6 7	March & September	..	..
11,334	£10	6/1	International Okonite Limited Ordinary	7⅞ 8⅛		7⅞ 8⅛		11 15 3	..	..	..
11,334	£10	5/0	Do. Preference	9¼ 9⅜		9¼ 9⅜		8 4 1	..	..	..
78,949	5	4/10½	Swan United (£3. 10s. paid) xd	4⅜ 5⅛		4⅜ 5		6 19 10	May and November	4⅞	4⅜
37,350	12	36/0	Telegraph Construction and Maintenance	45 47		45 47		5 0 0	March and July	47½	46½
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	102 105		102 105		4 15 3	January and July .	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£3 paid)	2⅛ 2⅝		2⅛ 2⅝		..	..	..	..
—	£5	..	Do. Preference (fully paid)	3⅛ 4⅛		3⅛ 4⅛		..	..	..	..
			RAILWAYS.								
50,000	£10	..	City and South London Railway	5½ 6½		5 6		..	..	..	..

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THE ELECTRICIAN:

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NOTES.

The reply of Dr. Fleming to the brief discussion on his exhaustive Paper dealing with a phenomenon which, for lack of a briefer name, has been called the Ferranti effect, will doubtless be the last word in a controversy which must have become somewhat wearisome to many of our readers. Mistaken accounts have been put forward both as to the tests made and the results obtained, and much unnecessary trouble has been expended on a matter the purely scientific interest of which is not supremely great and which is as yet of little practical importance. It was stated, during the discussion, that Dr. Fleming's Paper contained the first clear and true account of what was actually observed. Without going into the question of clearness, we venture to maintain that our leading article of 10th December, 1890, contained the first accurate statement, and described the way in which the rise of pressure was originally discovered by the engineers engaged in laying the mains.

We would remind our readers that Prof. Ewing will discourse at the Royal Institution, this evening, upon his very simple and beautiful theory of induced magnetism, and there is every reason to expect that this Institution will provide means for carrying out the experiments on a scale more in keeping with their importance than was found possible at the meeting of the British Association at Leeds, when they were first shown in public to an audience of some 20 persons or so, crowding round an apparatus inefficiently worked with a few cells.

A very remarkable confirmation of Prof. Ewing's theory comes to hand on the eve of the Royal Institution discourse, in the form of an article by Mr. Arthur Hoopes, in the *Electrical World* of New York, of May 16th. A mass of magnets, consisting of three layers of Ewing's needles, formed, as it were, the core of a magnetising coil. The magnetic moment of this coil was measured by a magnetometer, the usual precautions being taken to eliminate the influence of the magnetising current. The magnets were stirred up, and allowed to come to rest, a magnetising current was applied, and the magnetometer deflections carried through an ordinary **B-H** cycle. The result is a set of curves, jagged and discontinuous, it is true, but exhibiting all the well-known characteristics of the hysteresis curve. The small initial susceptibility is shown admirably, and even small loops superimposed on the main cycle are clearly represented, although only 68 needles were used.

We regret that it is impossible to convey to our readers by means of illustrations the extremely pretty experiment which embodies Prof. Ewing's theory. The first gradual inclination of the magnets, increasing to a distinct swerve in one direction; then the point at which instability begins, and the tottering of first one and then another needle, and the quick swing into a new position; then the unanimous facing about of the entire company; and, lastly, the gradual and decreasing effect of the strongest possible magnetising current upon the needles under its command, must be seen to be appreciated.

Workshop experiments, carried out by engineers, possess an advantage over laboratory researches of the student of pure science in that such experiments are generally carried out under the conditions of practical work, and their results are intended to apply directly to workshop practice; and such, to a large extent, has been the case in the interesting investigations which have formed the subject of the recent Paper by Mr. Vignoles. With a praiseworthy disinclination to acknowledge the applicability of the work of Hopkinson and Ewing to the design of transformers, the author, together with Mr. Evershed, started *de novo*, and, assuming nothing whatever, have made solid contribution to our knowledge of magnetism. Under these circumstances the fact that they have somewhat misused the term "induction," and have coined, for private use and with but little gracefulness, the word "thom," may, perhaps, be excused, for they do not set up as teachers, and ask no one to follow them.

It appears from the introduction to the Paper that the experimenters had applied themselves "to the consideration of the action of iron in transformers," but Mr. Vignoles informs us, in a letter which will be found in another column, that, iron alone being under consideration, leakage must not be taken into account, and on this ground he takes exception to the criticism which we made in our last issue. It is true that leakage has no influence on the form of the **B H** curve, but when **H** is calculated from the magnetising current in a particular coil, and **B** from the induction produced in a surrounding search coil, the curve so obtained may be affected by it. Our correspondent virtually admits our contention by stating the importance of the leakage question in transformers.

The action brought by the National Telephone Company against Mr. Andrew Erskine Muirhead, of Glasgow, a report

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of which will be found in another column, raised the delicate question of the meaning of "experimental use." Mr. MUIRHEAD, convinced of the superiority of the Ader and Berthon transmitters, proceeded last summer to advertise and circularise his convictions, with the natural result that the National Company brought him into Court. It was not denied that the transmitters in question were infringements of the patents owned by the National Company; but it was urged that the instruments were merely sent out for inspection and experimental use, no profit having been made by Mr. MUIRHEAD. The evidence on this point was somewhat conflicting. In the end, however, the National Company agreed to accept £50 damages, plus an injunction and the delivery up of the infringing instruments, the judge, to his manifest relief, being saved the necessity of defining where commercial use begins and experimental use ends.

OUR contemporary, the *Engineer*, in a short article on the reduction of the telegraphing rates to Australia under guarantee by the Australian Governments, makes the remark that "the costly cables which lie under the waves have only a partial use as yet." It is often assumed by those who have not had practical experience of submarine telegraphy that the whole 24 hours are available for transmitting messages, and this is sometimes in prospectuses made the basis for revenue estimates; but, as a matter of fact, the telegraphic working day between England and America, for instance, is only about 15 hours. Between Great Britain and Egypt practically the whole of the traffic must be carried between the hours of 9 and 5. In the case, however, of telegraphic correspondence between countries the difference of time between which is greater, the traffic is more evenly spread over the 24 hours; but even in this case the telegraphic working day is only about 18 hours. Australian time being 10 hours and Indian five in advance of English time, messages are as a rule sent one day and the replies received the next. The transmitting capacity of long cables is, however, strictly limited, and the existing sections to Australia being already duplexed, any very considerable increase in the number of messages would necessitate more cables. In fact, in view of the expected increase of Australian traffic, additional cables were laid from Suez to Bombay and from Madras to Penang at a cost of nearly one million sterling.

AN electro-magnet for the transport of iron castings has been in use for some time at Pittsburg, and the exhibition at Frankfort of one which is capable of lifting a ton, suggests the consideration of the question whether this is an economical or proper use of electric current. Of course, anyone who is connected to a supply company can heat baths and toast bread by electricity, but it would be an expensive amusement. A crane hook should have a factor of safety of 6. Should the magnetising current have a similar factor? The crane-hook will either support the load or it will snap; very rarely the first yielding may be detected in time. But an electro-magnet always has a certain (or uncertain) amount of "sticktion," and unless the current is interrupted, or the coils are short-circuited, it cannot fail to act. But if the casting be properly slung, the crane-hook cannot, on account of its shape, slip its load. Can the same be said of a magnet? The uncertainty of the good condition of the slings is eliminated, but there would seem to be some difficulty in both roughing a magnet so as to prevent lateral slipping, and at the same time providing sufficient surface. The economy of the matter is also rather obscure. A factor of safety of 6 in a crane-hook means that so much capital is invested in dead material, and is lying there, whether the hook be used or no; but as the current is only used while the lifting magnet is actually employed, the cost of the additional quantity demanded by the factor of safety is inconsiderable, always supposing there is a plentiful supply to draw upon. But the magnet itself must be of sufficiently large dimensions to allow the use of the large current; in fact, the magnet itself must be designed with an ample factor of safety. Electrical engineers are not so familiar with factors of safety as their mechanical *confrères*, and we doubt whether the application of electricity for the purpose of lifting and carrying iron castings will commend itself to the latter.

THE Electrical Exhibition at Frankfort promises to be a great success, and will afford some interesting information as to the popularity of various systems on the Continent. We publish this week the second of a series of articles which will be continued from time to time, and will describe some of the more important exhibits. The much talked-of transmission of 300 H.P. over 110 miles at a pressure of 25,000 volts will unfortunately be delayed until the middle of August.

The Electric Lighting of Barnsley.—We learn by telegraph, at the moment of going to press, that, at a meeting of the Barnsley Corporation, held yesterday, it was resolved to adopt the Lighting Committee's recommendations.

Royal Society.—The ladies' soirée of the Royal Society will take place on Wednesday, June 17th.

Society of Arts.—The conversazione of the Society of Arts will be held at the South Kensington Museum, on Wednesday evening, June 17th.

The National Telephone Electrical Society.—The second annual conversazione of this society was held at the Colonnade Hotel, New-street, Birmingham, on Friday, May 15th.

Stafford.—Telephone transmitters were recently placed in Christ Church, Birmingham, and receivers in the house of Dr. E. W. Taylor, of Stafford, where the service was followed with the utmost ease.

St. Pancras Vestry.—The Electricity Committee report that satisfactory progress is being made with the works in Stanhope-street, and that preparations are being made to put in the engines and dynamos. Also that the laying of the mains in Tottenham Court-road is progressing satisfactorily.

Boulogne.—Although this town possesses a large gas works the electric light has also been successfully introduced, a large Victoria dynamo, made by the Brush Company, having an output of 370 amperes at 120 volts, being employed to supply a number of the best shops in the town, where the light gives great satisfaction.

The Boy Messengers Company.—Mr. Richard King has now retired from active management of the Boy Messengers Company, which will be managed until it is taken over by the new Boy Messengers and Electric Call Company by the Hon. P. B. Lyon, who for nearly two years has been co-managing director with Mr. King.

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The Heilmann System of Electric Traction.—M. Heilmann will shortly carry out some experiments with a train equipped according to his system. M. Heilmann's idea, which was alluded to by our Paris correspondent in our issue of March 13th, consists essentially in replacing the ordinary railway locomotive by a 600 H.P. central station on wheels, supplying current to motors geared direct to the axles of the vehicles.

The Telegraph Extensions in Orkney and Shetland.—The telegraph steamer "Monarch" has finished the Pentland Firth cable, which was broken on the Orkney side of the Firth, and communication has again been restored by the direct route to the south. The "Monarch" is now lying off Kirkwall, and will, when the weather moderates, proceed to lay the new cable between Sanday and Westray.

Energy.—Matter, said Prof. Elihu Thomson in a lecture recently delivered at Lynn, was formerly considered as the thing that existed, and force the something that acted upon it. Energy is a term used to express something which we do not always understand. It exists everywhere so far as we know. Matter was considered indestructible. If we admit that energy can act on energy, we have no need of the old matter and force.

A Pulley Covering.—The Burt Pulley Covering Company, of Buffalo, N.Y., have brought out a substance known as Brazilian gum pulley covering. It is applied by means of a brush to the pulley, four coats being put on. After the last coat is on, the gum is allowed to harden for 12 hours, and then the face of the pulley is oiled with castor oil, or any good belt dressing, and the belt put on. This covering is said to prevent slipping of the belt.

Electricity in a Glass Factory.—The Pittsburg Plate Glass Company, of Ford City, Pa., is, says *Industries*, adopting the use of electric motors in its large plant in that city. The Company has a glass-polishing table which is said to be novel, and economical in comparison with similar machines. These tables are over 30ft. in diameter, and are revolved by gearing which has heretofore been operated by steam. The Thomson-Houston Company has now installed a 100 H.P. motor to operate these polishing tables.

Barnsley.—At yesterday's meeting of the Town Council, the following minute was submitted by the Park and Lighting Committee:—"The Committee recommend that in consequence of the withdrawal by the Westinghouse Electric Company of their tender, and of the withdrawal by the Board of Trade of their sanction to overhead wires, and of the large increase thereby occasioned in the cost of supplying electricity to the borough, the consideration of the present scheme be adjourned; and they further recommend that the borough surveyor be directed to prepare a scheme and plan for the supply of electricity to a smaller area, and to submit the same to the consideration of the Committee as early as practicable."

The Manufacture of Submarine Cables in France.—To the many reasons which militate in favour of the "telegraphic emancipation" of France, we may add, says *La Lumière Électrique*, a sad reminiscence of the *année terrible*. The Government having been obliged to quit Tours and take refuge at Bordeaux, communication with the Army of the North was of the slowest character. To overcome the difficulty Gambetta sent an agent to London to purchase a cable to connect Brest with Boulogne. The cable was paid for and taken on board a cable steamer, but at the moment when the vessel was getting under way the representations of the German Ambassador resulted in its detention.

The Societe Francaise des Telegraphes Sous-Marins.—The new network of this Company, starting from the north of Brazil, will run to Cayenne, Paramaribo, Martinique, and Guadeloupe. Thence the system will stretch across to St. Domingo and Cuba. From St. Domingo a cable will be run to Venezuela, touching at Curaçao. Martinique has given the Company an annual subsidy of £2,000 for 25 years, Guadaloupe one of £2,400, and French Guiana one of £4,000, each for 25 years. Dutch Guiana has voted an annual grant of £2,000 for 20 years, and Curaçao has guaranteed the Company a minimum annual income of £3,800 for 25 years. These subsidies amount in all to £14,200, a sum sufficient to pay the interest on the money borrowed by the Company to complete its system.

Science v. Art at South Kensington.—In a letter which appeared in *The Times*, of Wednesday, Profs. Ayrton and Armstrong remark—

> We cannot help thinking that a mistake has been made in calling public attention too exclusively to the housing of the science collections—the extension of the science schools appears to be a far more important matter. . . . The accommodation at present afforded by the Royal College of Science laboratories is not only inadequate, but beneath contempt in comparison with that to be found in Continental cities, such even as Göttingen and Zurich, for example; and those of us who have some knowledge of modern requirements know full well that every inch of space on the Imperial Institute-road side of the block of land on which stands the Natural History Museum will before long be required for the purposes of the Royal College of Science. The intrusion of an art gallery into this space would have a most disastrous effect by irretrievably preventing the proper and natural expansion of the Royal College of Science laboratories. . . .

Bath.—At a meeting of the Town Council last week, Prof. Forbes' report, an abstract of which appeared in our issue of April 24, with the remarks and recommendations of the Electric Lighting Committee, was submitted. The Electric Lighting Committee asked authority to adopt Prof. Forbes' recommendations:—(1) To retain a competent electrical engineer to make periodical visits—once a quarter—in order to test the condition of the circuits, to examine the street lighting, and to note the constancy of the electric pressure of the incandescent lamps; and (2) To authorise them to supply a few additional arc lamps to those parts where the lights are now too far apart. After a long discussion, in which differences of opinion were expressed upon the subject, the report was adopted.

The De Meritens Battery.—At the last meeting of the Société Internationale des Electriciens the report of the Laboratoire Central on the De Méritens battery was read. M. Hospitalier, however, elicited the fact that M. de Méritens had taken the battery under test away with him every evening. He further stated that the battery was really due to Baron d'Ebner, and was exhibited in the Austrian section of the Exhibition of 1867, and was described in the treatise of MM. Cazin and Angot in 1881. Moreover, the battery tested at the Laboratoire Central was not the same as the one tested by him; the zincs were larger in the proportion of nearly 4 to 1, the carbon was suppressed, and a porous pot was added, &c. Making, however, the necessary allowances for these facts, it was easy to see that the results arrived at corroborated those of M. Hospitalier.

Exports of Telegraph Apparatus.—The value of the exports of telegraph wires and of apparatus connected therewith during April was below the monthly average, and was very much less than in the corresponding month of last year. Owing, however, to the large exports in January and March, the figures for the four months still compare very favourably with the exports at the corresponding period of either last year or the year before. The following table gives the details of the value of exports for the four months, in comparison with the corresponding figures for the two previous years:—

	1891.	1890.	1889.
January	£238,223	£71,686	£113,230
February	22,306	201,594	32,086
March	392,552	51,390	285,993
First quarter	653,081	324,670	431,309
April	59,226	187,733	13,032
Four months	£712,307	£512,403	£444,341

Finsbury Technical College. Students' Conversazione.—In spite of the unpropitious weather, this conversazione, which was one of a series which have been held annually since 1885, was a decided success. In the basement a fountain had been contrived, tastefully decorated with palms and various tropical plants, from under which gleamed several prettily-arranged incandescent lamps. In the various rooms of the College representative firms displayed instruments and goods typical of almost every branch of electrical science. Instruction and amusement were alternately provided by a lecture on "Electricity in Motion," by Prof. Silvanus Thompson, who contrived to show a large number of interesting experiments in a comparatively short time, and by a concert given under the auspices of the Old Students' Association. By the courtesy of Dr. Wormel

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the proceedings concluded with a dance, held in the hall of the Cowper-street Schools, where some "Tableaux Statuaires" had also been provided early in the evening. Altogether, the Students are to be congratulated on the brilliant and successful way in which all the arrangements were carried out.

The West End Street Railway at Boston.—Work on the power house of the West End Street Railway Company of Boston is rapidly progressing, and the station will have over 13,000 H.P. capacity before winter. The station is arranged according to the usual American custom. The engines are arranged half on one side of the house and half on the other. The 28ft. driving pulleys of the engines have faces 10ft. 7in. in width. The power from each driving pulley is transmitted by means of two 5ft. belts, which lead over 7ft. pulleys upon the countershaft, having 5ft. 2in. faces, and running in pairs close together. Upon either side of the receiving pulleys are arranged 10ft. pulleys, having a 32in. face, from each of which a 30in. belt transmits the power to the pulley upon the shaft of the generators, located upon the floor above. The generator pulleys are 4ft. 8in. in diameter, and run at 400 revolutions. Each section of the countershaft is connected by means of clutches, so that when they are all connected there will be two lines of countershaft, each 250ft. in length, the shaft being 9in. in diameter. The entire plant will be duplicated as soon as possible after the first portion is in successful operation. The engines are by E. P. Allis and Co., of Milwaukee; the dynamos being multipolar Thomson-Houston machines. The West End Company have also been experimenting with various motors and trucks. Considerable attention has also been given to improvements in line and track construction.

Curious Electrical Phenomenon.—Some remarkable electrical phenomena accompanying the production upon the large scale of solid carbon dioxide are described, says *Nature*, by Dr. Haussknecht, of Berlin, in the current number of the *Berichte* of the German Chemical Society. In order to obtain large quantities of solid carbonic acid it is found most convenient in practice to allow the liquid stored in the usual form of iron cylinder to escape into a stout canvas bag. The liquid issues at pressures varying from 60-80 atmospheres, and a compact snow-like mass of solid carbon dioxide is formed in the canvas receiver. When the experiment is performed in the dark, the canvas receiver is seen to be illuminated within by a pale greenish-violet light, and Dr. Haussknecht states that electric sparks 10-20cm. long dart out from the pores of the cloth. Dr. Haussknecht further states that the phenomenon is very noticeable in the dark whenever there is a leakage in any portion of the compressing apparatus or the manometers connected therewith. The reason assigned for this development of statical electricity is similar in principle to that usually accepted in explanation of the hydro-electric machine of Sir William Armstrong. As the liquid carbonic acid is issuing from the valve it becomes partly converted into gas, which is violently forced through every pore of the canvas. Moreover, carried along with this stream of gas are great quantities of minute globules of liquid, which are brought in forcible contact with the solid particles already deposited. Dr. Haussknecht therefore considers that the electrical excitation is due mainly to the violent friction between these liquid globules and the solid snow. It is very essential for the successful reproduction of these electrical phenomena that the carbon dioxide should be absolutely free from admixed air; that prepared artificially yielding much finer results than that obtained from natural waters, which latter contains considerable quantities of air. The luminosity is not generally developed in the interior of the receiver until a crust of solid carbonic acid 0·5-1cm. thick has been deposited, which renders the probability of the correctness of the above theory all the greater.

The Manufacture of Insulators.—To obtain a thoroughly efficient insulator the greatest attention must be paid to its design, the quality of the material, and the nature of the glaze. The first process in the manufacture is the preparation of the mixture of the different ingredients, technically called "slip." This mixture, which is of a creamy consistency, is passed through a series of oscillating sieves, and is further stirred with a number of horse-shoe magnets to remove particles of iron. The "slip" having been thoroughly mixed, filtered, and purified, is forced by pumps through a press fitted with canvas bags, with the result that the water is squeezed out, and the clay sediment remains in the bags. This sediment, after being allowed a certain time to mature, is passed twice through a pug-mill, in which it is thoroughly kneaded. The prepared clay, as it comes out, is cut then into lumps, and pounded again, and kneaded by hand. The clay is now weighed out in lumps of a size to suit the insulators to be made The insulators are next roughly shaped by hand, and placed in a heated chamber and allowed to dry partially, till they have become sufficiently solid to admit of handling; they are then said to be in the "green" state. In this "green" state the clay is placed in lathes and turned in slotting and drilling machines; screws are cut, and the insulator is finished true to gauge. The insulators, now in the "white" state, are carefully examined for flaws. The perfect ones are placed in fireclay receptacles called "seggars," and built up inside circular kilns, or ovens, for firing. The process of baking takes from 36 to 48 hours, and great skill is requisite in the process. On removal from the oven the insulators are in what is called the "biscuit" state. They then go to the dipping house to be "dipped" in the glaze. This glaze is an important feature in the telegraph insulator, for while the leakage *through* the insulator depends upon the quality of the porcelain, the surface leakage depends largely upon the glaze. After being "dipped" in the glaze, the insulators are again placed in "seggars," and then passed into the glazing kiln. This completes the manufacture so far as the porcelain part of an insulator is concerned. The cups have next to be fitted with stalks, and are finally electrically tested.

Recalescence in Steel and Iron.—In the current number of the *Philosophical Magazine* Mr. F. J. Smith gives an account of some new methods of investigating the points of recalescence in steel and iron. The object of the experiments was to discover the time-connection which exists between the change of form and the change of temperature. Several methods of experimentation were tried, and the following was the one finally adopted. The upper end of the steel wire to be tested was fixed vertically; the lower end was attached to a long light lever of aluminium, so arranged that a small change of length of the wire caused a large movement of the end of the lever, which traced a line on the smoked surface of paper rotating on an ordinary physiological chronograph cylinder. A platinum-platino-rhodium thermo-couple, twisted round the wire where it was heated, was in circuit with a Deprez-D'Arsonval galvanometer. By means of this combination the temperatures at which the changes of length of the wire took place were read. The movements of the beam of light reflected from the galvanometer were recorded on a moving photographic film. The outcome of the experiments was that the changes of form of the metal under examination took place at the times of change of temperature, so that a curve so traced on the smoked paper can be used as an index of the changes of form and of the changes of temperature. Thinking it probable that these changes might be accompanied by some sounds at the critical points, the following apparatus was constructed:—A mica disc was fitted into a circular recess, turned out of a piece of wood. The steel wire under examination was attached at one end to the centre of the disc, at the other to a vertical post. The front of the recess into which the mica disc was fitted was furnished with two sounding tubes. On heating the wire a certain temperature was reached at which a sharp crackling sound was heard. As the temperature was increased this ceased; then, on removing the flame, at the same temperature at which the first sound was heard, a second similar sound occurred. This took place at the point of recalescence. As the wire cooled this ceased, and then, when a temperature of about 490°C. was reached, a very sharp sound was emitted. This third sound appears to take place at the second critical point observed by M. Osmond. The wire used in these experiments was steel pianoforte wire, annealed and straightened. The last experiment was also arranged so that the steel wire when heated should be in a strong magnetic field. Repeated trials showed that the sounds produced were in no way altered by the fact of the wire being in the magnetic field.

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ELECTRIC AND MAGNETIC THEORIES.

BY SILVANUS P. THOMPSON, D.SC.

(*Continued from page 45.*)

§ 7. Returning from these three fundamental cases, consider next the result of altering the arrangement of Fig. 1 so as to include both the A and B coils in the primary circuit. Now, reference to Fig. 1 will show that, when the key, K, is depressed to close the circuit, while the current in A is rising to its full strength, energy is thrown out into the medium, and passes laterally across into B, and there sets up (or *tends* to set up, if the circuit B is not actually closed) a current circulating in the opposite sense, as indicated by the two arrows in that diagram. If now, however, A and B are both inserted into one circuit, as in Fig. 4, there will still be a tendency, while the current is rising in A, for energy to pass from this part of the circuit into B, there to set up an opposing current. But at the same time, owing to the reception of energy from the source (which

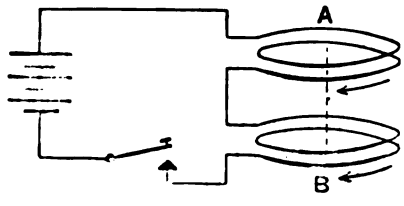

FIG. 4.

affects both A and B, though at present I do not discuss the precise mode), the current is rising in B also, in the same sense as in A. Hence, there is a tendency for energy to be transferred also from B to A, and to set up in A also a current in the sense opposed to that of the actual current. While these actions are going on, the current cannot rise as quickly to its full strength as it would if these actions were absent. And during this time energy is drawn from the battery, which does not manifest itself either in A or in B, but is, for the time being, employed in producing in the intervening medium a state of stress, thereby adding to the potential energy of the system. So long as the current flows around A and B this state of stress is maintained. When the current is stopped by raising the key, K, this energy returns back suddenly from the medium, laterally into the circuit, and appears in the form of light and heat, causing a brilliant spark at the key. These phenomena, *if taken by themselves*, might be compatible with the notion of propagation of

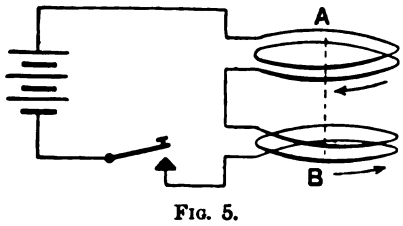

FIG. 5.

the current by longitudinal forces, and the propulsion of the current by an end-thrust, like water in a pipe; for one has only to suppose the current to be endowed with actual inertia to furnish a plausible account of the spark seen on opening the key.

§ 8. But now let us just simply suppose the connections of the coil B to be reversed, as shown in Fig. 5, so that the energy which travels laterally out of A shall now tend to help the current in B to flow, instead of tending to hinder it. It will also follow that the energy travelling laterally out of B to A will help the current in A to rise. As a result the current will rise both in A and in B more rapidly than it would have risen in either coil alone if the other were absent. More of the battery's energy will be directly expended in the conductor in heating it, and less will be stored up in the medium because the medium will not be put under so great a stress. On opening the key the spark at K will be far less than in the previous case, less than if either A or B were present alone.

§ 9. Now, consider by the light of these experimental facts the doctrine of end-thrust. It utterly fails to account for the difference between the two cases of Fig. 4, which produces a great spark, and Fig. 5, which produces practically none. Same coils, same battery, same current, same end-thrust—if there were any such thing at all—same inertia of current running along, like water in a pipe, but not the same spark on breaking. On the hydraulic analogy, with water flowing in a pipe, the two cases are identical, yet they produce wholly different effects. It is clear that the hydraulic analogy fails to account for the facts.

If, on the contrary, it is admitted that energy can be transferred from a circuit laterally into the surrounding medium, and can throw that medium into a state of stress, and can reenter a circuit laterally from the medium when the stress is released, then the facts become intelligible. What end-thrust entirely fails to account for is accounted for so soon as we realise that the energy which is necessary to make a current rise in a wire may be, and is, imparted to it laterally through the surrounding medium.

§ 10. Now let me briefly review these cases up to the point at which we have arrived. In cases 1, 2, and 3, the energy beyond all dispute passed into B through the medium, laterally to the so-called direction of the flow of current. In those cases there was no conducting wire by which the energy could have passed from A to B, and the only conceivable mode of transfer was by the medium. In case 4, although there was a connecting wire joining B to A, energy, nevertheless, passed across the medium as before, and set up a stress in it; and by contrast between case 4 and case 5 it was seen that if energy were merely transmitted by the wire, like water in a pipe, by an end thrust, 4 and 5 would have been identical in their effects, whereas, in fact, their effects are different.

In all these cases we have been dealing with currents of varying strength. We shall have to deal with the case of steady currents flow in the next section.

(*To be continued.*)

THE FRANKFORT ELECTRICAL EXHIBITION.

(FROM OUR OWN CORRESPONDENT.)

The Frankfort Electrical Exhibition was opened on Saturday last under very favourable circumstances.

Leopold Sonnemann, the Chairman of the Committee of the Exhibition, in the course of his address to the Empress Frederick and other invited guests, said that after eight years of rapid progress in all branches of electrotechnology it had been thought good to hold a review of what had been accomplished. In order to give an idea of the extent of the Exhibition in comparison with the previous ones held in Germany, he mentioned that the first German electrical exhibition, in Munich, in 1882, had at its command only 160 H.P.; in the second, at Vienna, in 1883, the horse-power had already risen to 1,200 H.P.; while at Frankfort this year 4,684 H.P. would be in use. The Finance Minister, Dr. Miguel, then declared the Exhibition open.

A brief review of some of the principal features of the Exhibition may be of interest at this moment, more detailed descriptions being deferred until the exhibits are in a more forward state. The boiler-house lies directly behind the great Machinery Hall, and here are 21 boilers of various kinds and sizes, of which 20 are already in use or ready for use; the total heating surface of these is more than 27,500 square feet. Among these may be mentioned two of 2,300 square feet heating surface, each by Steinmüller, of Gummersbach, which provide, through steam engines of a total of 430 H.P., the necessary power for Schuckert and Co.'s dynamos and those of Woodhouse and Rawson, of London. Paucksch, of Landsberg, has three combined boilers of 2,600 square feet heating surface, which serve for the two dynamos of the Helios Company, of Cologne, one of which is of 600 H.P. Simonis and Lanz, of Frankfort, have

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two boilers of 2,700 square feet heating surface each. A large gallery running round the boiler-house enables visitors to inspect the boilers without disturbing the stokers and attendants.

The great Machinery Hall is, perhaps, the portion of the Exhibition which will attract most attention. Here there are more than sixty prime motors, of which many are already in use. The larger dynamos are mostly coupled directly to the steam engines, especially in the case of firms which build both dynamos and steam engines. In respect of the dynamos exhibited, it is to be noticed that the alternate-current machines are almost as numerous as the direct, and there have evidently been great efforts to obtain examples of the largest types of both kinds. The 100 H.P. dynamo of Edison was thought in 1881 to be excessive, but here we have machines of 300, 500, and 600 H.P.

Siemens and Halske, of Berlin, have undertaken the erection of a central station for the distribution of electric current. They occupy a large space on the extreme right of the Machinery Hall, and their installation will shortly be complete. The direct-current installation consists of a three-cylinder compound steam engine by Kahn, of Stuttgart, and a direct-coupled interior-pole dynamo of 500 H.P. The current will by means of a direct-current transformer be supplied at the necessary pressure for the charging of a battery of 168 Tudor accumulators, having a capacity of 540 H.P. hours, arranged in two parallel rows. A portion of the current, by means of a second transformer, will be used for an electric tramway. The alternate-current installation includes a two-cylinder compound steam engine by Buckau (Magdeburg), to which is directly coupled a 400 H.P. alternator, and an interior-pole machine coupled directly to a steam engine by Daevel, of Kiel. The alternating-current is transformed into a continuous current by a 200 H.P. step-down transformer (2,000-150 volts), to charge accumulators, and by a 100 H.P. and a 50 H.P. transformer to supply current for lighting purposes. By means, also, of four step-up transformers (2,000-20,000 volts), a portion of the current will be delivered for lighting the main Exhibition, the requisite cable being from Siemens Brothers, of London.

Schuckert and Co., of Nuremburg, whose installation is also not quite ready, exhibit several steam engines from 270 H.P. downwards, and many dynamos and motors; they also undertake the lighting of a great part of the Exhibition. The Thomson-Houston Company, of Hamburg, show in the Machinery Hall two dynamos, one of about 40 kilowatts (180 amperes × 220 volts) for transmission of power, and a 17·5 kilowatt machine for arc lamps and glow lamps in series. In the workshops buildings, they have an electro-magnet capable of lifting a weight of one ton, intended for the transport of iron castings in ironworks.

The Helios Company, of Cologne, occupy the central part of the Hall, and, after the Siemens and Halske exhibits, this Company's space will probably prove the most attractive; moreover the greater part of their exhibits are ready. On the south side of the Hall they have a 600 H.P. steam engine by Paucksch, of Landsberg, coupled to a 2000-volt 400-kilowatt alternator. This machine, besides supplying lighting current to the Exhibition ground, will deliver 30,000-watts for lighting purposes at the Palm Gardens at the other end of the town. They have also a 200 H.P. steam engine, by Sulzer, of Winterthur, driving a 2,000-volt 40-ampere alternator, and a direct-current machine giving 65,000 watts at 110 volts. Various other machines are also erected on their site.

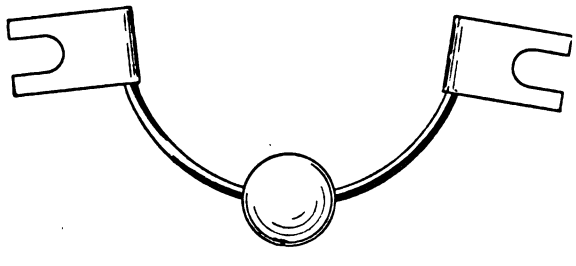
The entire output of the dynamos worked by steam is put down at 3,747 H.P.; those run off gas engines give 203 H.P. Altogether, about 31 firms are showing dynamos, electromotors and transformers, while 20 exhibit steam engines and 12 firms gas engines. The large size of the Machinery Hall prevents overcrowding, and the machines are placed in such a manner as to be of easy inspection by the visitor. The execution of the project for the transmission of 300 H.P. from Lauffen-on-the-Neckar to the Exhibition has unfortunately been delayed. It was found that the necessary transformers and insulators could not be procured in as short a time as was anticipated. The two firms which have undertaken the scheme, namely, the Allgemeine Electricitäts Gesellschaft, of Berlin, and the Maschinenfabrik of Oerlikon, have, however, bound themselves under penalty to have the system in working order by August 15. There seems, then, no doubt that this important experiment, which is awaited with so much eagerness, will be carried out. The manufacture of the conductors is already commenced by the Post Office authorities, and the 10,000 large insulators which will be necessary have been ordered. It will be remembered that the electricity is to be generated by means of an alternator driven by water-power on the Neckar, and that the current is to be generated at a pressure of 50 volts, transformed up to 25,000 volts, and transmitted by three wires of 4mm. thickness across the 110 miles of country separating Lauffen from the Exhibition.

After the Machinery Hall we come to the department for the Distribution of Electricity, which has a separate building devoted to it at the back of the Machinery Hall. The exhibits here are not ready. Here are shown transformers, both alternating and direct, of all kinds, pressure regulators, automatic rheostats, &c. Running down either side of this are the workshops, the motive power of which is derived from the Machinery Hall. The technical arrangements of these workshops are in the hands of Engineers Sarasin and Stahl. Some 35 motors of different types, and varying from $\frac{1}{15}$ to 25 H.P., are at work. The current is derived from three sources—partly from the main Machinery Hall; partly from the electrical station set up at the Palm Gardens, distant about three-quarters of a mile; and the rest is transmitted from Offenbach, about seven miles up the Main. From the two last-mentioned places the current is transmitted overhead at a high pressure, and transformed down to the necessary low pressure. One of the most interesting of the workshops will be the glow lamp manufactory, of Maatschappy, Gelnhausen; and another the manufacture of small lathes and clocks, &c., by Wolf, Tahn and Co., of Frankfort, small Hartmann and Braun motors being used.

Finally, on the left of the Machinery Hall, a large pile of earth has been heaped up, on one side of which is a large pond, with an artificial waterfall running into it down the side of the mound, which produces beautiful effects when lighted up from underneath by electricity. On the top of the mound is a convenient restaurant, with a tower illuminated by numerous glow lamps. A model mine is arranged under the mound, with underground electric railway, electric boring machines, &c., and lamps which ought to make gas explosions out of the question.

AN IMPROVED FUSE.

The weak point about the fuses in ordinary cut-outs is in the attachment to the terminals. The tin wire generally used is excellent as far as easy and prompt melting is concerned, and it is



Improved Fuse.

free from oxidation, but it is too soft to afford sufficient resistance to the pressure of a screw head or clamp. If eyelets are used, the screw must be completely removed, and the eyelets and screws do not always agree in size. Sir David Salomons has sent us a specimen of a fuse which we illustrate herewith. The ends of the tin wire are held in clamps of sheet copper about 15 mils in thickness, affording a contact of large surface. The slotted hole enables the copper contact piece to be easily removed by only slacking back the screw half a turn or so. The idea is not patented, and we are asked to publish it in order that no one else may patent it.

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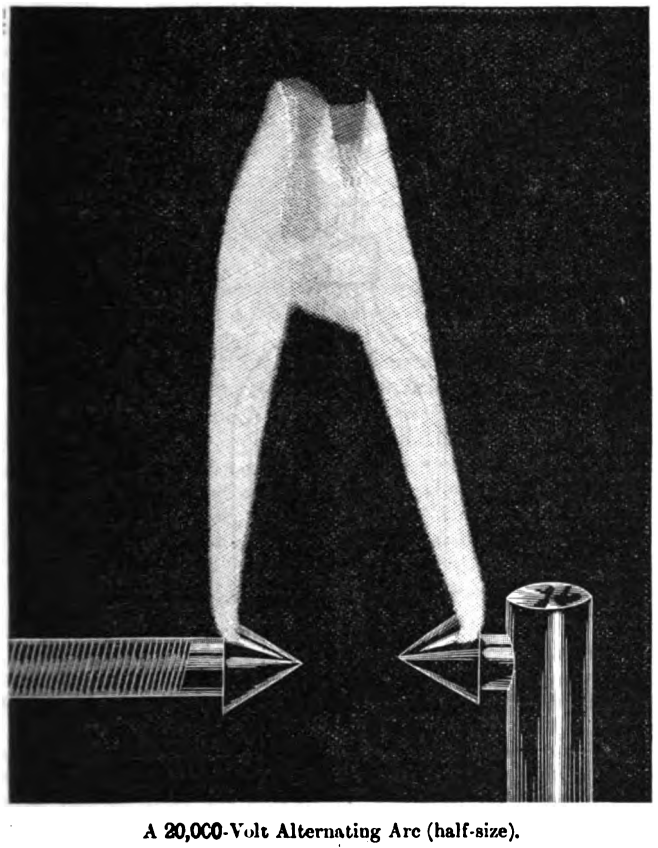
EXPERIMENTS WITH HIGH-TENSION ALTERNATING-CURRENTS.*

Messrs. Siemens and Halske, of Berlin, recently invited the members of the Elektrotechnishe Verein of that city to their works to witness the demonstration of a series of experiments on alternating-currents under a pressure of 20,000 volts. In order to show that the desired pressure was really *en evidence*, the high tension was conducted through a pair of wires of only 0·2 mm. diameter to a battery of 200 100-volt incandescent lamps, all connected up in series. An ordinary Siemens electric light cable was inserted, and broke down at a pressure of some 15,000 volts.

At the end of the meeting a few experiments on the formation of the arc under this enormous pressure were shown. The sparking distance varied considerably according to the shape of the electrodes. At 20,000 volts a spark jumped from a ball to a ball about 10 millimetres, while between two points a sparking distance of 30 millimetres, and sometimes even more, was reached. This arc is shown half size in the accompanying engraving.

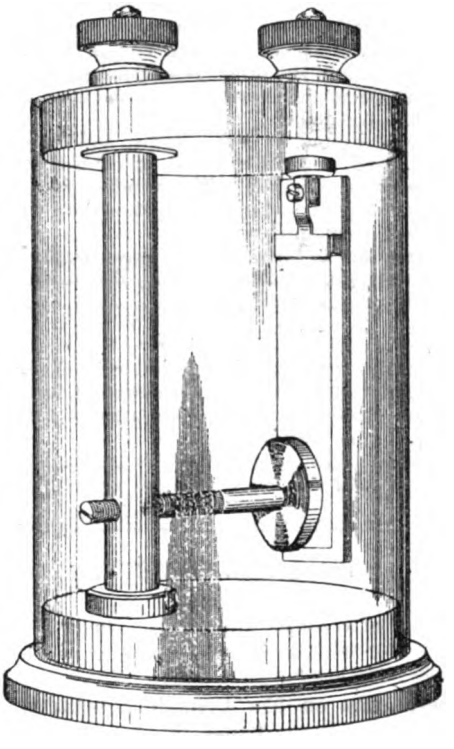


A 20,000-Volt Alternating Arc (half-size).

The arc which followed the jumping over of a spark made a loud humming and clapping noise, and flapped about, being easily carried away by the slightest draught. The arc could be drawn out horizontally to something like 100 millimetres distance between the electrodes, and even to a distance of 150 millimetres, when carbon pencils were used as electrodes, but it always remained standing up in a point.

AN ELECTROSTATIC SAFETY DEVICE.

This device, as shown in the accompanying illustration, is a glass cylinder fixed on an ebonite base, and closed at the top by an ebonite cap. A solid brass rod runs from top to bottom, and near the bottom, and at right angles to it, is fixed a smaller adjustable rod, terminating in a flat head. Opposite to this flat disc there is a brass strip secured to the ebonite cap. From the top of this brass strip hangs a gold or aluminium foil. The foil and strip are placed to earth, and the solid brass rod is connected to the circuit to be protected. Should the difference of potential between the foil and the terminal opposite to it attain more than a certain amount, electrostatic

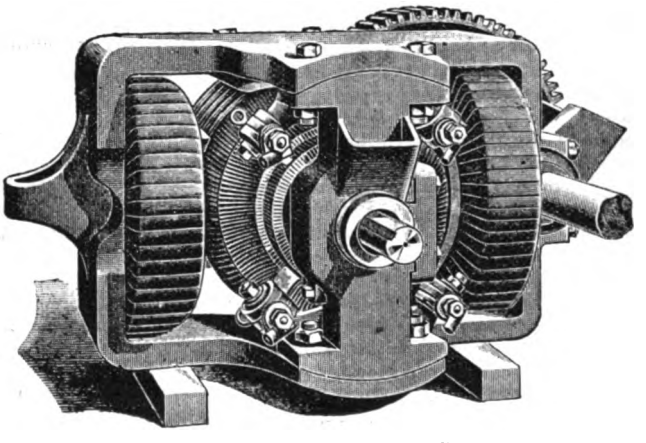


attraction will cause the foil to touch the disc, and place the circuit to earth. The apparatus, which is a modification of the Cardew earthing device, is constructed by Messrs Drake and Gorham, of Victoria-street.

* From the *Electrical Engineer* of New York.

THE NEW EDISON SINGLE-REDUCTION STREET CAR MOTOR.*

In the accompanying illustration is shown the new multipolar single-reduction gear street car motor, recently brought out by the Edison Company of America. The motor is of the 4-pole type, and practically iron-clad. Only two poles, those in the horizontal



New Edison Single-Reduction Street Car Motor.

plane, are wound with coils. The entire field-magnet frame, consisting of special soft cast steel, is made in one casting, with the exception of the pole-pieces, which are attached by screw bolts after the spools have been slipped on over the straight cores at the sides.

In the construction of the machine the facing of the armature bearing and the cylindrical armature space are bored out at one

* From the *Electrical Engineer* of New York.

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boring, and by loosening two bolts the armature can be slipped out completely, so that inspection can be effected with great facility. The armature, which is of the Gramme type, is built up of punched soft iron rings insulated from each other, and with the end plates of wrought iron and bevelled.

The diameter of the armature is 18in., and its length 13in. The shaft is 3in. in diameter, and upon each end is mounted a pinion which meshes with the large gears at each end of the axle, thus equalising the power on the axle. One end of the magnet forms the car axle bearing, and the other is suspended by a spring at the nozzle for easy starting. The commutator has been made specially large, being 10in. in diameter.

The armature is wound in 140 sections, and on account of the strong field employed, and the method of connection to the commutator, no spark is observed. The winding is put on in one continuous length of wire, and at each section a tap wire of German silver is taken to the commutator.

The entire machine is encased in a water-tight cover, and its total weight, with gears, is 2,200 pounds. The machine is rated at 25 H.P., but will readily develop 30 H.P. It is intended to apply two of these machines to each car of the double truck type, while one machine alone will be ample to drive the smaller cars. The motor is of the series type, and the regulation is effected by varying the combination of the fields, which are wound in three sections. The four carbon brushes employed are rigidly fastened to the frame, and require no shifting throughout the range of load to which the motor is subjected. The motor is calculated to revolve at 460 revolutions with the car running at a speed of 12 miles an hour.

PHYSICAL SOCIETY.

At the meeting of the Physical Society, held at Cambridge in the Cavendish Laboratory, on Saturday, May 9th, the following communications were made :—

"Some Experiments on the Electric Discharge in Vacuum Tubes."

BY PROF. J. J. THOMSON, M.A., F.R.S.

The phenomena of vacuum discharges were, he said, greatly simplified when their path was wholly gaseous, the complication of

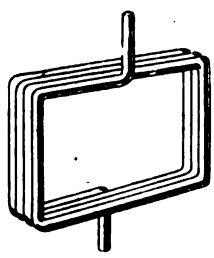

Fig. 1.—Coil of glass tube for vacuum discharge experiments. The primary coils are filled with mercury, the secondary coils form continuous closed circuits.

the dark space surrounding the negative electrode and the stratifications so commonly observed in ordinary vacuum tubes being absent. To produce discharges in tubes devoid of electrodes was, however, not easy to accomplish, for the only available means of producing an electromotive force in the discharge circuit was by electro-magnetic induction. Ordinary methods of producing variable induction were valueless, and recourse was had to the oscillatory discharge of a Leyden jar, which combines the two essentials of a current whose maximum value is enormous, and whose rapidity of alternation is immensely great. The discharge circuits, which may take the shape of bulbs, or of tubes bent in the form of coils, were placed in close proximity to glass tubes filled with mercury, which formed the path of the oscillatory discharge. The parts thus corresponded to the windings of an induction coil, the vacuum tubes being the secondary and the tubes filled with mercury the primary. In such an apparatus the Leyden jar need not be large, and neither primary nor secondary need have many turns, for this would increase the self-induction of the former and lengthen the discharge path in the latter. Increasing the self-induction of the primary reduces the E.M.F. induced in the secondary, whilst lengthening the secondary does not increase the E.M.F. per unit length. Two or three turns (Fig 1) in each were found to be quite sufficient, and, on discharging the Leyden jar between two highly-polished knobs in the primary circuit, a plain uniform band of light was seen to pass round the secondary. An exhausted bulb (Fig. 2) containing traces of oxygen was placed within a primary spiral of three turns, and, on passing the jar discharge, a circle of light was seen within the bulb in close proximity to the primary circuit, accompanied by a purplish glow, which lasted for a second or more. On heating the bulb the duration of the glow was greatly diminished, and it could be instantly extinguished by the presence of an electro-magnet. Another exhausted bulb (Fig. 3), surrounded by a primary spiral, was contained in a bell-jar, and when the pressure of air in the jar was about that of the atmosphere the secondary discharge occurred in the bulb, as is ordinarily the case. On exhausting the jar, however, the luminous discharge grew fainter, and a point was

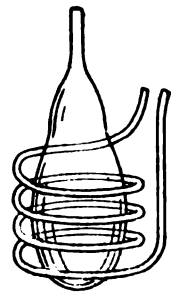

Fig. 2.—Exhausted bulb surrounded by primary spiral consisting of a coiled glass tube containing mercury.

reached at which no secondary discharge was visible. Further exhaustion of the jar caused the secondary discharge to appear outside the bulb. The fact of obtaining no luminous discharge either in the bulb or jar the author could only explain on two suppositions, viz., that under the conditions then existing the specific inductive capacity of the gas was very great, or that a discharge could pass

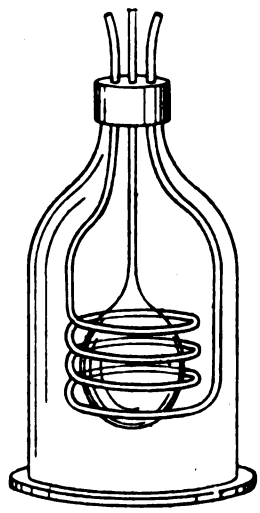

Fig. 3.—Exhausted bulb surrounded by primary coils, enclosed in bell jar.

without being luminous. The author had also observed that the conductivity of a vacuum tube without electrodes increased as the pressure diminished until a certain point was reached, and afterwards diminished again, thus showing that the high resistance of a nearly perfect vacuum is in no way due to the presence of the

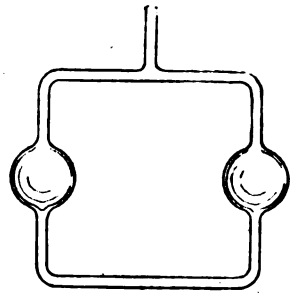

Fig. 4.—Exhausted secondary coil of one loop containing bulbs. The discharge passed along the inner side of the bulbs, the primary coils being placed within the secondary.

electrodes, One peculiarity of the discharges was their local nature, the rings of light being much more sharply defined than was to be expected. They were also found to be most easily produced when the chain of molecules in the discharge were all of the same kind. For example, a discharge could be easily sent through a tube many

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feet long, but the introduction of a small pellet of mercury in the tube stopped the discharge, although the conductivity of the mercury was much greater than that of the vacuum. In some cases he had noticed that a very fine wire placed within a tube on the side remote from the primary circuit would prevent a luminous discharge in that tube.

"Some Experiments on the Velocities of the Ions."

BY W. C. D. WHETHAM, B.A.

In studying electrolysis, the question as to whether there is any transference of solvent when a porous wall is absent presented itself to the author. The ordinary methods of testing for transference, such as by increase of pressure, or by overflow, not being available, when there is no diaphragm, the author used different coloured solutions of the same salt, such as cobalt chloride in water and in alcohol, the former of which is red and the latter blue. By putting the solutions into a kind of U-shaped tube (Fig. 5), any change

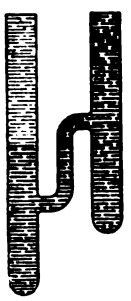

FIG. 5.—U Tube for measuring velocities of ions.

in the position of the line of junction of the two liquids could be measured. Two aqueous solutions in which the anion was the same were also tried, one combination being cupric chloride and common salt, and in this case the line of demarcation traversed about 7in. in three hours. The results hitherto obtained by this method agreed fairly with those found by Kohlrausch.

'On the Resistance of some Mercury Standards."

BY R. T. GLAZEBROOK, M.A., F.R.S.

In 1885 M. Benoit, of Paris, supplied the author with three mercury standards, nominally representing the Paris Congress ohm, now commonly known as the legal ohm. Tests of these standards were described in a Paper read before the Physical Society in 1885 by the present author. Recently he had occasion to compare two of the standards with the British Association coils. The mean of many concordant results gave the resistance of one of the mercury standards (No. 37) as 1·01106 B.A.U.; whilst that of the other (No. 39) was 1·01032 B.A.U. Expressing them in legal ohms the present resistances are (No. 37) ·99986 and (No. 39) ·99913, whilst in 1885 the values obtained were (No. 37) ·99990 and (No. 39) ·99917. This shows that within the limits of experimental error the ratios of the mercury standards to the B.A. coils have remained practically unchanged during six years. The numbers given above are based on Lord Rayleigh's determination of the specific resistance of mercury which differs appreciably from that found by Mascart and other observers. Taking the mean of the later concordant determinations the value of the mercury standards expressed in legal ohms become (No. 37) 1·00033 and (No. 39) ·99959. The values given by the maker were 1·00045 and ·99954 respectively, showing a very close agreement. The author also found that refilling No. 37 from the same sample of mercury produced no appreciable change in its resistance whilst No. 39 was somewhat affected by a similar operation. Experiments on the co-efficient of increase of resistance of mercury with temperature gave the value ·000872, as the mean co-efficient between 0° and 10° C., a number rather less than that obtained by Kohlrausch.

DISCUSSION.

In the discussion on Prof. Thomson's Paper, Prof. FITZGERALD said the beautiful experiments were likely to lead to very important results. He did not quite understand how placing a fine wire in a vacuum tube could prevent the luminous discharge; for, if the wire was on the side remote from the primary, and if there was any great increase in specific inductive capacity, he would have expected the air to screen the wire.

Prof. LODGE asked for further information as to the action of the magnet in preventing the afterglow, and in some cases precipitating a luminous discharge. The experiment with the exhausted bulb within the bell-jar was also difficult to understand, and he did not see why one of Prof. Thomson's two suppositions must necessarily be true.

The PRESIDENT (Prof. Ayrton) inquired whether Prof. Thomson had tried Mr. Crookes' experiment, in which the electric pressure necessary to produce a discharge was greatly lessened by putting a phosphorescent material in the tube.

Prof. THOMSON, in reply, said he had not tried the experiment, but the phosphorescence he had observed was of quite a different character to that produced in Mr. Crookes' tubes. To Prof. Fitzgerald he said the action of the wire was probably a question of time, and thought the whole field was in some way thrown on the wire, and thus discharged. In reply to Prof. Lodge, he had not ascertained the true nature of the effect of a magnet on the glow; but he believed the glow to be due to a combination which might be prevented or facilitated by the action of the magnet causing the density to be different in different parts of the bulb.

On the motion of Prof. AYRTON, seconded by Prof. RUCKER, a hearty vote of thanks was accorded to the authors for their valuable and interesting communications, and for the kind manner in which the Society had been received and entertained by the Cambridge members. Prof. Thomson and Mr. Glazebrook acknowledged the vote.

ON THE MOST ECONOMICAL MODE OF FEEDING A LOW-PRESSURE NETWORK.*

BY R. E. CROMPTON, VICE-PRESIDENT.

The advocates of alternating transformer (hereafter called the A.T.) system of distribution, appear at last to be in agreement with those who designed low-pressure systems, in that they admit that for the supply of towns of ordinary compactness a low-pressure network must be provided. Their practice in the future is to diverge from their practice in the past, in that they fix the transformers only at the feeding points of the network, instead of in each of the consumers' houses. In other words, they propose to use high-pressure feeders, consisting of cables carrying a high-pressure primary current, transformed so as to supply a low-pressure network on either the two or three-wire system, by a transformer fixed at the feeding point. Mr. Ferranti, Mr. Gordon, and other gentlemen advocate banking the transformers at these feeding points, and the use of automatic apparatus to switch their transformers in as the load requires. Others, such as Mr. Mordey, prefer to spend more money on the perfecting of a design of a single transformer at the feeding point, so as to avoid the complication of automatic apparatus. As it was evident that there is a certain length of feeder at which the low-pressure direct system fails to compete successfully in first cost and that of up-keep with the above-described high-pressure A.T. feeder, I have recently investigated the question in order to find out at what mean length of feeders the low-pressure and high-pressure systems compete on equal terms of first cost, cost of up-keep, and efficiency. The result of my investigation is to show that when a three-wire low-pressure system, distributing direct to 110-volt lamps, is compared with an A.T. system, distributed by 2,000-volt feeders, transformed to supply the same three-wire network, the average annual efficiency of the feeders in both cases being 90 per cent., the low-pressure feeder is cheaper for all distances up to 2,400 yards, each of the feeders being calculated to supply 100 kilowatts; and the annual cost for up-keep, including a sum of 5 per cent. for interest on the capital, will be about £290 per annum. These large figures lead me to compare with them the known cost of up-keep of feeders carrying the same load which are now in use in London. I find that feeders of an average length of 600 yards cost about £300 each, and for interest and up-keep £25 per annum. This comparison shows that if we increase the length of each feeder by 1,800 yards, or say one mile, it increases the supply company's annual up-keep charges by not less than £260 per annum per feeder. If we apply these figures to a company supplying a district of about a square mile, which, if it had within it two generating stations, could feed its network with 10 short feeders, and substitute for these two central stations, one external generating station one mile distant from the outside of the district, the extra cost of up-keep of the 10 long feeders will be £2,600 per annum. At a load factor of 10 such a district would sell 876,000 units per annum; therefore the above sum of £2,600, divided by this number of units, is equal to 0·72 of a penny per unit sold. Now, even at present the cost per unit for coal and ground rent (which are the only two items affected by the removal of the site from a central position to a distant point) only slightly exceeds 1d. a unit, and in all probability during the present year this figure will be brought down to a sum approximately the same as the above-mentioned up-keep of the feeders, viz., 0·72, which I have shown is the actual cost of up-keep of the feeders only. This shows the absurdity of imagining that any saving can be effected by this mode of feeding a network, and it is quite evident that those who have advocated the system have never seriously looked at the matter from this point of view. In such cases where really great savings can be effected by generating the

* Paper read before the Institution of Electrical Engineers, May 14, 1891.

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Table I.—*Comparison of Cost of* 100-*Kilowatt Feeders.*

—	A. 220-volt low-pressure feeder. Mean annual efficiency, 90 per cent. 450 yards bare copper; 150 „ cable in pipes; total, 600 yards.	B. 220-volt low-pressure feeder. Mean annual efficiency, 90 per cent. 1,800 yards bare copper; 600 „ cable in pipes; total, 2,400 yards.	C. 2,000-volt A.T. feeder, with transformer in pit. Mean annual efficiency, 90 per cent. 2,400 yards concentric cable, laid in part of low-pressure culvert or in open.
	£	£	£
Excavation, or extra width culvert and pipes, at 5s. per yard	150	600	600
Transformer pit	...	...	60
Bare copper, at £90 per ton, laid	78	1,260	...
Low-pressure cable (250 volts), rubber insulation, laid	65	1,020	...
High-pressure cable (concentric), 2,000 volts, laid	...	...	1,300
Transformer and apparatus, including fixing	...	...	440
Total	£293	£2,880	£2,400

Table II.—*Cost of Up-keep of* 100-*Kilowatt Feeders.*

—	A.	B.	C.
	£ s. d.	£ s. d.	£ s. d.
Culvert and pipes, &c., at 1 per cent.	1 10 0	6 0 0	6 0 0
Transformer pit, „ 2½ „	...	...	1 10 0
Bare copper „ 1 „	0 15 8	12 12 0	...
Low-pressure cable, „ 8 „	5 4 6	81 10 0	...
High-pressure cable, „ 8 „	...	...	104 0 0
Transformer and apparatus, „ 10 „	...	...	44 0 0
Small apparatus	2 10 0	10 0 0	10 0 0
Interest on total, 5 per cent.	14 13 0	144 0 0	120 0 0
Total	£24 13 2	£254 2 0	£285 10 0

energy at a distance from the district to be supplied, as in the case of water power, Mr. Ferranti's original Deptford scheme of supplying one or two large transformer stations by currents of very high E.M.F. is in all probability the right one; but the distribution must be modified from Mr. Ferranti's original intention: that is to say, he need not transform twice, but merely supply several transformer stations by his high-pressure mains, and feed the surrounding districts by not only a low-pressure network, but also low-pressure feeders. I have not at command the figures as to the cost of mains of extreme high pressure such as Mr. Ferranti advocates; but I have no doubt that he will be able to show, even for such distances as one or two miles, a very considerable saving on the separate feeder system that I have just criticised.

Table I. shows you the details of first cost of the 600 yards low pressure, 2,400 yards low pressure, and 2,400 yards A.T. feeder with transformer.

Table II. shows the details of cost of up-keep of the same three feeders. It will be noticed I have taken the cost of up-keep on excavation or concrete work below ground at 1 per cent. per annum, on the transformer pit at 2½ per cent. per annum, on the bare copper at 1 per cent, on both low and high-pressure cables at 8 per cent.; although I might well claim that the cost of up-keep of the high-pressure cable would be a higher percentage on its first cost than the low. The transforming and switching apparatus I have taken at 10 per cent., and I have added a small charge for the up-keep of surface and inspection boxes. This is taken without reference to pressure, in proportion to the length laid. The cost of the low-pressure feeders has been carefully taken out in accordance with our London practice, and that of the high-pressure feeder has been taken out from estimates received from cable and transformer makers. I believe that these figures may be said to be sufficiently correct to make the comparison a fair one; at any rate, I think no one will venture to say that either the first cost or up-keep is taken at too high a figure. For the purposes of my argument they are sufficient to show that 100-kilowatt feeders of 2,400 yards long cannot be put down at less than £1 a yard, and cannot, including transformers, be maintained at less than 2s. 4d. a yard per annum.

The Electrical Manufacture of Phosphorus.—Dr. Readman, at the May meeting of the Glasgow Section of the Society of Chemical Industry, gave a description of the new works and plant which have been erected at Wolverhampton for the manufacture of phosphorus by the Readman-Parker patents. The process consists in decomposing the mixture of phosphoric acid, or acid phosphates and carbon, by the heat of the electric arc imbedded in the mass.

RAILWAY TRAIN-LIGHTING.*

BY WILLIAM LANGDON.

The author stated that the desirability of a better illumination of railway carriages had been long felt. The lamps originally provided were intended simply to enable passengers to enter and leave the carriages without inconvenience, but the exigencies of the present time called for the additional luxury of a reading light. The illuminants in use were rape oil, paraffin oil, compressed gas, and electricity, and the author dealt with the recent advances which had been made in connection with the last.

In October, 1881, a Pullman car, running between Victoria and Brighton, was lighted by electricity, and the experiment was so far successful that it was extended to the entire train, and at present there were 16 trains so lighted belonging to the Brighton Company. Mr. Houghton, the Company's electrician, and the late Mr. Stroudley, were the pioneers of the application of electricity to this purpose. An interesting experiment, devised by Mr. W. H. Preece, was tried on the London and South-Western Railway in 1883-4. The movement of the train was employed to compress air into a chamber, and the air so compressed was used to drive a dynamo to furnish the current for the lamps. In July, 1886, the Great Northern Railway applied electric light to one of their metropolitan trains. The Taff Vale and Cheshire lines had also made experiments in the same direction. In all these cases the lighting was effected by means of a dynamo driven from the axle of the guard's van combined with accumulators stored in the same vehicle. In August, 1884, the London and North-Western Railway tried a different principle in fitting up a short train which was still running between Manchester and Liverpool. The current was produced by a dynamo driven by a Brotherhood engine fixed to the tender and supplied with steam from the boiler of the locomotive.

In this, however, as in the previous cases, the lighting was effected from one point, and should the train be broken up the part severed from the source of current would be left in darkness. In 1888, the Directors of the Midland Railway authorised the equipment of two trains to run between London, Manchester, and Liverpool, in which the following conditions were to be fulfilled, viz.:—(1) Each vehicle was to carry its own lighting power. (2) Each vehicle was to be capable of being coupled and uncoupled and turned about as needed, without the possibility of the connections being wrongly made. (3) The coupling must readily draw apart when coaches were slipped *en route*. (4) The act of drawing the coupling apart must make all the changes in the connections necessary to transfer the lamps from the dynamo circuit of the train to

* Abstract of a Paper read before the Institution of Civil Engineers, May 5, 1891.

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the accumulator circuit of the carriage itself. (5) Each compartment was to carry not less than two lamps. (6) The lighting throughout the train was to be capable of being turned on or off from any one of the guard's vans. For the sake of experiment, one of these trains was equipped on the "parallel" system, the other on the "series" system. The former, having proved the best, had been adopted by the Company, and there were now five trains leaving St. Pancras daily which were electrically lighted, and in which the dynamo was driven off the axle of the guard's van, each vehicle being provided with accumulators capable of supplying the necessary current without the assistance of the dynamo.

There was also a local train travelling between Manchester and Stockport lighted after the plan adopted by Mr. Houghton on the Brighton line, but equipped with two sets of accumulators and two dynamos driven from the axle. In addition to the foregoing, there were two trains running between London and Bedford, the dynamos of which were driven by small high-speed engines placed on the locomotive.

Dynamos.—The first trains fitted on the Midland Railway were furnished with machines giving a practically constant output of current, no matter how few or how many were the carriages attached. Messrs. Holmes and Co., of Newcastle, had since succeeded in making a dynamo which afforded a current proportional to the resistance of the circuit, and these machines were employed on all main line trains in which the dynamos were driven from the axle.

Accumulators.—These were of the "E.P.S." type. With main-line trains, where each vehicle carried its own batteries, the type employed was C 15 for the larger, and C 11 for the smaller carriages. In all cases the electrical pressure was 35 volts, so that 18 cells were necessary for each.

Electrical Coupling.—Where trains were not broken up, the difficulty of providing an efficient electrical coupling was not so great, but where the marshalling of carriages had to be smartly dealt with at terminal or intermediate stations, the coupling must be such as not only to provide a good electrical connection, but to admit of easy handling. The form adopted by the Midland Company effected these objects in a perfectly satisfactory manner. On a coupling being separated, the lights were automatically turned on. If the lamps were not required, the coupling, instead of being allowed to hang down, was placed upon a "dummy," the effect of which was to turn the current off. For slip coaches special provision was made.

By the insertion of a small resistance in each battery parallel, a fair distribution of the current throughout the different vehicles was attained, and in order to meet the increased pressure when the dynamo was in circuit, a sufficient additional resistance was automatically introduced. The lamps were of 8 c.p., and there were two in each compartment.

With regard to the second mode of generating the current, namely, by dynamos placed on the locomotive, it was believed that at present no other trains save the three already referred to were equipped in that way.

The total number of electrically-lighted vehicles now in operation on the Brighton, Great Northern, and Midland systems was 365 coaches and 57 vans.

In conclusion, the author pointed out that the main points to be determined were whether electricity was safe, reliable, and less costly than other illuminants. The fact that electrically-lighted trains had now been running for a considerable period without accident would appear conclusive evidence of its safety, and experience had shown that there was no reason to doubt its reliability where efficient provision had been made; and the author believed that, when the cost of applying any of the illuminants, whether oil, gas, or electricity, to a complete railway system was taken into account, the latter would be found the most economical. The cost of oil was between ½d. and 1d. per lamp per hour. So far, compressed gas had never been employed for lighting the entire stock of any railway, with the exception of the Metropolitan Railway—which was specially adapted for its application. To consider the cost as applied to stock devoted to certain traffic would hardly afford a true basis of comparison. Where gas was used entirely, depôts must be established at each point at which trains were made up, whilst at busy centres it would probably have to be conveyed some distance by pipes laid down for the purpose. The cost of fitting coaches for gas varied from £4. 8s. to £7 per lamp, while for electricity it was £4. 3s. 4d. per lamp. For trains running which were not broken up on the journey the cost per lamp amounted to £3. 12s. Vans with dynamos cost from £250 to £300 each. Statistics were given showing that the cost for maintenance in the case of gas was from ·045d. to ·250d. per light per hour. There was reason to believe that the total cost of compressed gas, when applied to an entire system, would exceed ½d. per lamp per hour, while the actual cost for electricity, as used on the Midland Railway, had not greatly exceeded ½d. per lamp per hour.

THE TELEPHONE AS AN OPTICAL CURRENT MEASURER.*

BY MAX WIEN.

The author arranges his "optical telephone" as follows:—A thin corrugated German silver membrane, such as is used for aneroid barometers, is provided at the middle of that side which is towards the electro-magnet with a piece of soft iron and on the other side with a pin. The latter presses against a piece of very fine watch-spring steel, one end of which is fixed, whilst the other carries a very light mirror. A telescope is used to throw the image of an illuminated slit on the mirror.

If a constant current is allowed to pass through the apparatus, the membrane changes its position of equilibrium; the beam of light is displaced, and remains so so long as the current does not alter. This displacement is proportional to the current intensity, and can be experimentally regulated. Since the telescope allows 100 divisions of the scale by tenths to be observed, and one division may be made to correspond to about 5×10^{-5} amperes, a conclusion as to the sensitiveness attainable can be arrived at.

Although the "optical telephone" is thus highly suited for constant currents, it is still better adapted for those which alternate. If a simple sine current passes through the apparatus, the membrane vibrates and with it the mirror. Instead of an ordinary displacement a band of light is then produced, the breadth of which is a measure of the amplitude of the sine current.

It is, however, necessary that the natural tones of the membrane and the spring and the number of alternations of the sine current should be in correspondence with one another. This may be easily effected so far as the membrane and the spring are concerned, and also for the current, if the latter is derived from an induction coil, the contact breaker spring of which is brought to the right tone.

By comparing the results with those given by a dynamometer, the proportionality between the displacement and amplitude of the current was experimentally established. The author shows how with his apparatus he has measured self-induction and fluid resistance with alternating currents. Finally, he gives a table showing the conductivity of dilute sulphuric acid of specific gravities between 1·200 and 1·250. The maximum value $691{\cdot}9 \times {\cdot}10^{-7}$ is reached at a temperature of 17·3° C. at a specific gravity of 1·224.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

FRIDAY, May 22nd. (To-night.)

PHYSICAL SOCIETY OF LONDON.

5 p.m. Papers to be read: (1) "Dr. Schobben's Form of Lantern-Stereoscope," by C. J. WOODWARD, B.Sc. (2) "A Simple Steam-Engine Indicator accurate at any speed," by Prof J. PERRY, F.R.S. (3) "Mr. Blakesley's Method of Measuring Power in Transformers," by Prof. J. PERRY, F.R.S. (4) "Alternate Current and Potential Difference Analogies in the Methods of Measuring Power," by Prof. W. E. AYRTON, F.R.S., and W. E. SUMPNER, D.Sc.

ROYAL INSTITUTION.

9 p.m. Evening Discourse. "The Molecular Process in Magnetic Induction." By Prof J. A. EWING, F.R.S.

SATURDAY, May 23rd.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Artificial Production of Cold." By H. GRAHAM-HARRIS, M. Inst. C.E.

TUESDAY, May 26th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Cibber Period of Stage History." By WILLIAM ARCHER.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Annual General Meeting to receive the Report of the Council, and to elect the Council and Officers for the ensuing year.

THURSDAY, May 28th.

ROYAL INSTITUTION.

3 p.m Afternoon Lecture: "The Orchestra considered in connection with the Development of the Overture." By A. C. MACKENZIE.

SOCIETY OF ARTS.

4.30 p.m. Indian Section. Paper to be read: "The Study of Indian History." By CHARLES LEWIS TUPPER, B.A.

FRIDAY, May 29th.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "An Astronomer's Work in a Modern Observatory." By DAVID GILL, F.R.S.

SATURDAY, May 30th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Scientific Study of Decorative Colour." By Prof. A. H. CHURCH, F.R.S.

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The Electrician.

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ELECTRICAL DISCHARGES IN VACUA.

The experiments shown by Prof. J. J. THOMSON before the Physical Society, on the occasion of its most enjoyable excursion to Cambridge, form a new departure in the very interesting study of electrical discharges in vacua. The early researches in this direction served rather to enwrap in mystery the action of the luminous discharge in vacuum tubes. The dark space at the negative electrode, and the varied forms of striæ which appear to have their origin at the positive pole; the difference of potential required to produce a discharge under various degrees of exhaustion; the thermal and magnetic effects, and numerous other beautiful experiments have been minutely examined by GASSIOT, PLÜCKER, DE LA RUE, MÜLLER, and others, while the, as it were, artificial production of stratified discharges, and the curious sensitive state of vacuum tubes, has formed the subject of a very interesting research by SPOTTISWOODE and MOULTON. Even then the examination of the discharge in vacua was left in a very undeveloped condition, and when Prof. SCHUSTER dealt with the subject of the discharge of electricity through gases before the Royal Society, only about a year ago, in his Bakerian lecture, he threw out several bold speculations as to chemical actions in the dark space, and suggested, without any fear of contradiction, that the striæ were due to decomposition, diffusion of ions, and subsequent recombination. A modification of these views has indeed been put forward also by Prof. J. J. THOMSON.

Prof. CROOKES' researches, which have been spread over so many years, and have recently, in their collected shape, formed the subject of his presidential address, have not consisted in

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the investigation of electrical discharges under natural or forced conditions, but in the utilisation of them as a means for studying the fourth or radiant state of matter, and the behaviour of molecule streams and other kindred phenomena. In this respect, as well as the accidental coincidence that he dispensed in certain cases with actual electrodes, the experiments of Prof. CROOKES compare with those of Prof. J. J. THOMSON. The latter has been using vacuum tubes for carrying out researches of a very different character to those of DE LA RUE and SPOTTISWOODE, and has, indeed, dispensed with the tube form, and induces or produces the discharge in mid air, or rather in mid vacuum. But the work of the two present investigators suggests contrast as well as comparison. Both sets of experiments are of great interest, both are very pretty. Neither of them are of any practical use, and may therefore be studied in scientific tranquility, undisturbed by the company promoter or the prospectus writer. But the one research is pervaded with a mathematical and the other with a chemical instinct. The former tends directly to quantitative results and the latter to qualitative. It is difficult to say if one is more definite or tangible than the other. Both are seasoned with a little controversial animus, for Prof. CROOKES triumphantly pointed to the absence of electrodes, as disproving Dr. PULUJ'S electrode matter hypothesis; while Prof. J. J. THOMSON successfully refutes the strange doctrine that a perfect vacuum is a perfect conductor. On the whole, perhaps, the experiments shown in the Cavendish Laboratory, pervaded as they were by the mathematical spirit of the place, appeal more forcibly to, and are more suggestive for most physicists, if only because they are of a less transcendental order.

Electrical discharges through more or less attenuated gases afford one of the most promising directions in which we may study matter, ether, and, if it be not already abandoned as an entity, electricity. Hitherto these discharges have been very much complicated by the disturbing effect of the electrodes, so much in fact that in many cases there is little else than the terminal effects to be seen. Prof. J. J. THOMSON has, however, not only got rid of the conducting wires, as Prof. CROOKES has done, but he has treated the vacuum tube in an altogether new and effective way. It has hitherto been customary to include a vacuum tube in part of a circuit, but here, by making it the secondary of a transformer or induction coil, it forms a complete, closed, and self-contained circuit in itself. The elimination of the electrodes has an important bearing on the conductivity of a vacuum. Air at ordinary pressures is commonly treated as our best and practically perfect insulator; but when rarefied, it has an apparent conductivity which increases to a maximum, as in the condition of ordinary vacuum tubes, and then diminishes enormously as a true vacuum is approached. This is an instance of the danger of attempting to extend hypothesis beyond the limits of actual observation, for, if good air-pumps had not been invented, it might have been imagined that the resistance of a vacuum was practically nothing, and, by the dangerous principle of symmetry, that it *was* nothing. So tempting was this idea, that the doctrine to which we have referred has been seriously put forward, and it has been suggested that the surface of the electrodes entirely accounted for the resistance. Such a resistance has been observed in a very striking manner in the simple experiment described in the report of the Paper which will be found in another column. We have spoken of the conductivity as apparent, and intended this guarded expression to apply rather to that which is conducted, for the discharge in a rarefied gas does not behave as a current. It has been shown by DE LA RUE that it does not obey Ohm's law. If a double route be provided, it will not divide itself as a current would do, in two portions, proportioned to the conductivities, but it selects one route.

A vacuum discharge is not then a case of simple conduction. SPOTTISWOODE and MOULTON say "one terminal does not feel the electric state of the other directly, as would be the case were they metallically connected, but pours forth its electricity in the shape of free electricity, and leaves it to wander at its own will in that shape." If it could thus wander in a simple straight tube, what might it be expected to do in a mere bulb with no terminals at all? It has a definite direction, as has been proved by the 50ft. vacuum tube at the Cavendish Laboratory, and this supports, to some extent, the conventional idea of an electric current. Strange to say, the discharge in a bulb surrounded by a "primary coil" is manifested in the form of a luminous ring, and that not a broad one; it is accompanied by a lingering glow, unless the bulb be warmed. But it here again behaves unlike a current, and, selecting the path of least resistance or of greatest stress, the *whole* of the discharge takes place along that route, perhaps because it is there that a path is broken through. There is no finite lineal current, but an endless ring, presenting the old puzzle of electromotive force without difference of potential or voltage. The lines of force encircling a current are commonly regarded as a consequence, not as a concurrence, and are usually unimportant in a conductor; but, with the rapid oscillations used in these experiments, it is possible that their direct effect is to render the attenuated gas luminous, and the glow itself is called a discharge or a current. On the other hand, that a true discharge or current is set up was conclusively proved by providing several long lengths of tube, which, while forming part of the closed secondary circuit of the transformer, were not subject to the magnetic field, and yet exhibited a glow precisely similar to that which was seen in the coils directly influenced by the primary coils.

In view of the well-known dark space in ordinary vacuum tubes, and of the fact that in a stratified discharge the portions between the striæ are sometimes entirely devoid of glow, and, further, of the observations of DE LA RUE and MÜLLER, who suspect the existence of invisible striæ even in the dark discharge, since they detected a development of heat in the middle of a tube in which there was no illumination except at the terminals, it is not safe to say that when no luminous band is to be seen in one of these closed circuits there is no discharge, and still less safe is it to account for the non-appearance by supposing the velocity of the discharge to be that of light. Prof. THOMSON, in reply to the remarks of Dr. LODGE, observed that although a firm believer in MAXWELL'S theory, he did "not believe that everything went with the velocity of light." It is rather a fault of Maxwellians that they try to prove every velocity to be the same as that of light in air, forgetting how this velocity varies in different substances and for different kinds of light.

OBITUARY.

EDMOND BECQUEREL.

In the person of M. Edmond Becquerel there passes away a notable figure from the ranks of Continental electricians. Born at Paris, March 24, 1820, he had just completed his seventy-first year; the greater part of this long life having been spent in active scientific work. His father, the veteran Antoine César Becquerel, the friend of Davy, Faraday, de la Rive, Ampère, Arago, and all the notabilities of the former generation, died at the age of ninety, in 1878. From 1823 to 1863 he had worked incessantly at electro-chemistry, atmospheric electricity, and kindred problems; and in many of the later

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of these researches his son Edmond was associated with him. We find the son, brought up amongst scientific associations, early developing a passion for research. When but twenty years of age he presented to the Academy of Sciences at Paris a thesis "On Some Chemical and Electrical Effects produced under the influence of Solar Light. In the preceding year, 1839, he had joined with his father and with the Academician Biot in the preparation of a memoir on the phosphoresence resulting from the light of electric discharges. This memoir was printed in the archives of the Museum of Natural History in Paris, where the elder Becquerel held the Professorship of Physics, to which many years later the younger Becquerel succeeded. He continued his father's researches on electro-chemical phenomena, and made, in 1856, a very complete study of the electromotive force and internal resistance of primary batteries. In 1853 he attacked the difficult problem of the transmission of electricity through gases at high temperatures. In 1861 he made a study of the conductivity of liquids in capillary tubes, and showed that by this means a rheostat might be constructed having many hundreds of thousands of times as much resistance as the kilometre of telegraph wire then used as a standard of comparison. At one time he paid much attention to the subject of magnetism, and conducted a series of researches on the diamagnetic properties of bodies, using for that purpose an electro-magnet of a size which at that date—1846—had scarcely been equalled in power. He also made an examination of the distribution of magnetism in very attenuated wires of steel. In conjunction with his father he was the author of several important treatises. In 1847 they published a work on the elements of terrestial physics and meteorology. This was followed in 1855 by a treatise on electricity, the third volume of which, on magnetism and electro-magnetism, was mainly by Edmond Becquerel; the first being on statical electricity and general phenomena, and the second on electro-chemistry. In 1858 they brought out a résumé of the history of electricity and magnetism, a work conspicuously illustrative of the strong, as well as of the weak, points in French historiography.

But Becquerel's work was not confined by any means to electrical subjects; it was in another department of physics that his life's work was mainly accomplished. He devoted himself with all the eagerness of his nature to the recently-discovered chemical effects of light; and for many years he continued to pour forth memoirs of his experimental researches upon this and kindred branches of optics. It was he who discovered that all the colours of the spectrum can be impressed upon a photographic film of chloride of silver, provided it has been already faintly illuminated by an ultra-violet ray to start the sensitive state. It was he who discovered the de-sensitising effect of the infra-red (or "heat") rays, and by means of this phenomenon proved the existence of absorption lines or bands in this invisible region of the spectrum of solar light. He made the subject of phosphorescence peculiarly his own. He devised the "phosphoroscope," wherewith to study phosphorescent bodies and the duration of the period during which they emit their light. In 1867, being then Professor of Physics at the Conservatoire of Arts and Industries, he published two splendid volumes entitled: "Light, its Causes, and its Effects." In this work he collected all that was known on the subject of the emission and production of light, on its relations to heat and electricity, on its analysis by the prism, and on the phenomena of fluorescence and phosphorescence. He made a special study of the production of phosphorescence by exposure to light, and of the remarkable phosphorescent qualities of the sulphides of the alkaline earths, of which the modern "luminous paint" is the outcome. This work remains his masterpiece, and will long be consulted as the standard treatise on these subjects.

During the last fifteen years, as age told upon him, he relinquished active research work; and he was latterly surrounded by men of a younger generation, who were absorbed in newer problems, in which he had no part. His place is, however, worthily filled by his son M. Henri Becquerel, who has already made his mark in researches both in optics and in magnetism, and who carries forward the honourable traditions of scientific devotion with which the names of his father and grandfather are associated.

ON SOME EFFECTS OF ALTERNATING-CURRENT FLOW IN CIRCUITS HAVING CAPACITY AND SELF-INDUCTION.*

BY DR. J. A. FLEMING.

(Continued from page 49.)

15. In the course of various experiments during the laying of the cable, it became evident that a conductor having so considerable an electrostatic capacity behaved in a curious manner under some circumstances when long lengths were connected up to a transformer. This behaviour has been much misunderstood, and much misdescribed. Remarkable phrases have been coined with reference to it, such as "the piling up of the volts," or "packing up of the volts," which are not very lucid descriptions of what really does occur. Ingenious theories have been constructed, also, to account for phenomena which do not exist. Briefly stated, it appears to be as follows:—When an insulated and sufficient length of the cable has its inner and outer members connected to the terminals either of a transformer or of an alternator having an armature of sufficient inductance, it is observed that under these conditions the potential difference between the inner and outer members, measured anywhere along the length of the cable, is generally greater than would be the potential difference of the terminals of that alternator or transformer if the cable were very short, or not present at all. This seems to hold good also when the far ends of the inner and outer members are connected together through a not very small resistance, such as a row of incandescent lamps in series, or a high-resistance voltmeter, or transformer lightly loaded. The cable acts in all apparently as one single condenser would do, and in no case, as far as is known, is there evidence of a continuous rise of pressure along the trunk mains themselves. The pressure at the London end is not found to be greater than at the Deptford end. The condenser effect is increased apparently by increase of length of the main, at least within observed limits, and in all cases the main acts as if it were a condenser bridged across between two parallel mains without capacity. When current flows into the cable there is a flux across the dielectric from inner to outer member which constitutes the *condenser current* of the mains, and the outflowing current is in general less in magnitude than the inflowing current, although not always necessarily so. The current flowing out at the London end may be called the *work current*. There is a difference in phase between the work current and the condenser current. The ingoing current is the resultant of the work and condenser current.

16. In order to examine the phenomena of these trunk mains more closely, some experiments were made on one length of nearly 12 miles of the cable by joining the conductors of two trunk mains in London, and having both ends of this gigantic loop of concentric cable at our disposal in the Deptford station. These experiments were arranged by Mr. Ferranti to give Mr. Preece, Major Cardew, and me the opportunity of obtaining measurements of these condenser effects in the Ferranti trunk mains. The experiments were made on Friday, January 9, 1891, at Deptford, and Mr. Ferranti, Mr. Sparks, Mr. D'Alton, Mr. McLean, and the assistant engineers took part in carrying out these measurements. The arrangements were made as follows (see Fig. 10):—One of the 1,200 H.P. dynamos (No. 2) was set apart for the purpose, and excited so as to supply current at about 2,500 volts or so. The current from this dynamo was led through the primaries of two 150 H.P. transformers joined in parallel, and which raised the pressure from 2,500 to 10,000 volts. At this pressure a current from the secondaries was sent into the concentric cable at Deptford, thence to the sub-station in Trafalgar-square in London by one main, and back to Deptford on the other trunk main. This total distance is 20,224 yards, or 11·49 statute miles. Arriving back at Deptford, the current was again reduced from 10,000 to 2,500 volts, and the energy taken up in water resistance in a water tank at the latter pressure. The pressure at different parts of the system was measured by Cardew voltmeters, the high pressures being reduced by 100: 1 pilot transformers. The currents were measured by Evershed ammeters. The current and pressure were measured at four places—viz., at the terminals of the dynamo, at the beginning or entrance of the trunk main, at the end of the trunk main, and, after reduction, at the tank. Observers stationed at these different instruments took simultaneous observations at a signal given by the sound of a whistle, and in this way the simultaneous values of the pressure and current were obtained at these four places. The transformers used for raising and lowering the pressure were the 150 H.P. size, having on the primary side 1,120 turns of wire, of resistance 3·5 ohms, and on the secondary side 280 turns of wire, having a resistance of ·2442 ohms. Hence these transformers were 4 : 1 transformers. There were, in addition, a pair of pilot transformers, which had a change ratio of

* Paper read May 7, 1891, before the Institution of Electrical Engineers.

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100 : 1, and which reduced from 10,000 to 100 volts for voltmeter purposes. The observations consisted in exciting the dynamo to various voltages, and observing the current and pressure at the four places named, whilst different loads were placed on the system by taking up more or less current in the tank.

17. From a large number of observations the following are selected as showing the general results obtained, and are set forth in Table I. The first column gives a number for each experiment. The second and third give the pressure and current at the dynamo terminals. The fourth column is a series of numbers which are four times those in the second column, and are the pressures to which the 1 : 4 step-up transformers at the home end would raise the dynamo pressure if the cable were absent. The fifth and sixth columns give the pressure and current at the home, or dynamo, end of the trunk main, and it will be seen that in every case this observed pressure is greater than four times the pressure at the dynamo terminals. The seventh and eighth columns give the pressure and current at the far end of the trunk main, and it will be seen that in every case the current flowing out of the main is less than that going into it. Columns X. and XI. give the pressure and current after reduction by the step-down transformers, at which pressure the energy was taken up on water resistance in a tank. Column IX. gives the pressure on the primary, or cable, side of the 4 : 1 step-down transformers, which would be necessary to give the pressure observed at the tank if the cable were not present.

18. We have then to see how these observed values agree with theory. It must be, however, stated that these numbers and values so observed are not minutely accurate. Owing to the fact that the speed of the dynamo varied slightly, and to the fact that the Cardew voltmeters used were set vertical, and not horizontal, some degree of inaccuracy exists in the readings of current and pressure, but the figures are perhaps sufficient to test the general agreement of fact with theory.

We note, first, that in the experiments at full load, when 118 amperes was being taken up in the resistance, the load on the transformers was about 340 H.P., and hence the two 150 H.P. transformers at each end joined in parallel were slightly over-

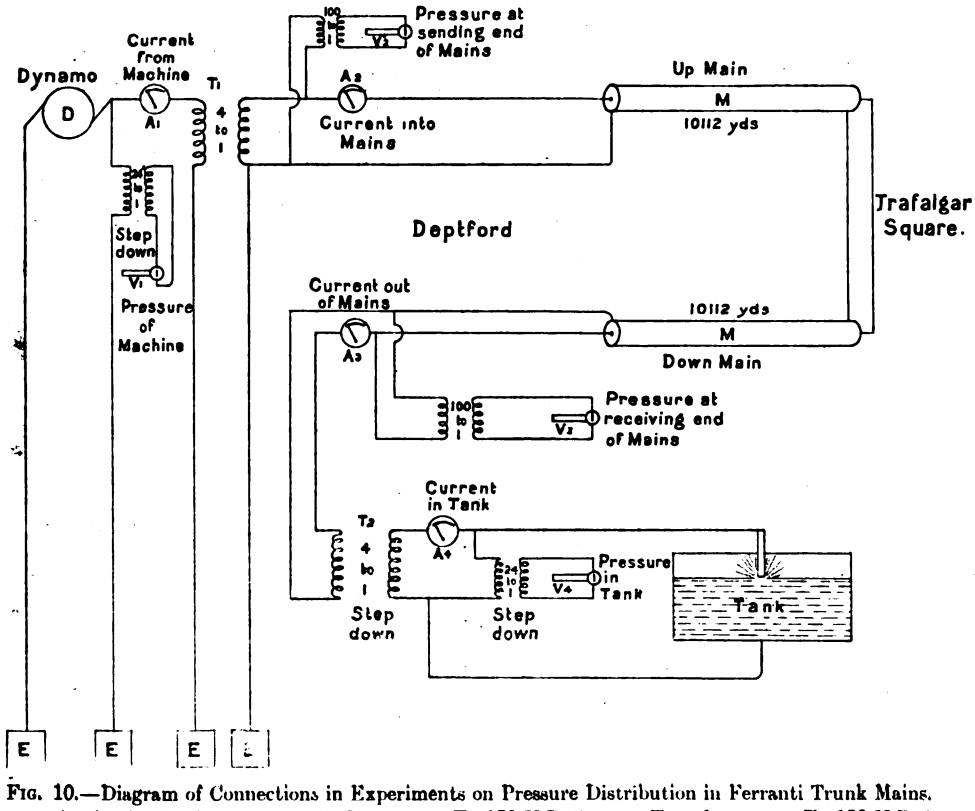

FIG. 10.—Diagram of Connections in Experiments on Pressure Distribution in Ferranti Trunk Mains.
V_1, V_2, V_3, V_4, Voltmeters. A_1, A_2, A_3, A_4 Ammeters. D, Dynamo. T_1, 150 H.P. Step-up Transformers. T_2, 150 H.P. Step-down Transformers. M, Trunk Mains. Tank, Large Water Tank into which a copper bar carrying the current was lowered to take up energy. E, Earth Plates.

Table I.—*Experiments on the Pressure Distribution in the Ferranti Trunk Mains.*

I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.
No. of Experiment.	At Dynamo Terminals.		Dynamo Pressure multiplied by 4.	At Home End of Trunk Main.		At Far End of Trunk Main.		Pressure at Tank multiplied by 4.	At the Tank.	
	Pressure.	Current.		Pressure.	Current.	Pressure.	Current.		Pressure.	Current.
1	2,177	121·4	8,708	9,060	29·2	8,950	26·5	8,640	2,160	118·2
2	2,385	119·4	9,544	10,100	31·5	9,770	28·0	9,504	2,376	117·1
3	2,458	119·4	9,832	10,300	32·0	10,120	28·0	9,840	2,460	116·0
4	2,177	119·3	8,708	9,110	29·2	8,930	26·5	8,640	2,160	116·0
5	2,311	113·2	9,244	9,700	28·7	9.570	24·8	9,408	2,352	106·5
6	2,251	110·2	9,004	9,600	27·6	9,280	24·3	9,024	2,256	105·5
7	2,568	106·1	10,272	10,490	27·0	10,070	23·3	9,792	2,448	101·6
8	1,994	108·1	7,976	8,420	26·0	8,200	23·3	7,872	1,968	100·7
9	2,448	100·0	9,792	10,170	24·0	10,690	19·0	10,128	2,532	56·6
10	2,496	92·8	9,984	10,560	22·0	10,590	17·0	10,512	2,628	56·0
11	2,400	92 8	9,600	10,360	21·5	10,490	16·3	10,224	2,556	55·5
12	2,311	64·1	9,244	9,700	17·0	9,770	Not taken	9,600	2,400	42·2
13	2,280	41·7	9,120	9,870	11·0	9,900	0	9,735	2,434	0
14	2,328	41·7	9,312	9,970	11·0	10,000	0	9,880	2,470	0
15	1,620	42·7	6,480	7,240	10·0	7,350	0	7,248	1,812	0
16	1,104	24·4	4,416	5,200	5·0	5,200	0	4,964	1,241	0
17	1,212	24·4	4,848	5,500	9·0	5,500	0	5,456	1,339	0
18	1,308	24·4	5,232	5,900	9·0	5,900	0	5,740	1,435	0
19	1,800	37·6	7,200	7,920	10·0	7,920	0	7,784	1,946	0
20	2,136	48·8	8,544	9,380	12·0	9,410	0	9,244	2,311	0

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loaded. Under these circumstances, the inductance of the transformers at the step-up end is reduced practically to a very small value, and we may consider that the actual current of 30 amperes or so flowing in the cable can be considered to be the resultant of two superimposed currents differing about 90 degrees in phase from one another. There is, first, the *work* current of 26·5 amperes in Experiment I. which is flowing out of the cable, and which is practically in synchronism with the impressed electromotive force in the secondary circuit of the step-up transformers. Then there is the *condenser* current of the cable considered as one single condenser, which will be 90 degrees in advance in phase of the impressed electromotive force creating this charge. Hence the values of the ingoing currents given in column VI. are the resultants of the outgoing currents given in column VIII., and the condenser current of the cable, which is in quadrature with the last. Hence the magnitude of the condenser current must be the square root of the difference of the squares of the currents given in columns VI. and VIII., which may be called respectively the *resultant current* and the *work current*.

Taking the first six experiments in Table I., we calculate from them the square root of the difference of the squares of the currents in columns VI. and VIII. of Table I., and write them as in Table II. below.

Table II.

Resultant current going into cable $=a$.	Work current coming out of cable $=b$.	Condenser current of cable $=\sqrt{a^2-b^2}$.
Amperes.	Amperes.	Amperes.
29·2	26·5	12·2
31·5	28·0	14·4
32·0	28·0	15·5
29·2	26·5	12·2
28·7	24·8	14·4
27·6	24·3	13·1

Unfortunately, the speeds of the dynamo were not taken at each observation; but the normal frequency of the current from these dynamos is 67, and in these experiments the dynamo speeds were marked as rather below the normal. If $n=67$, $2\pi n=p=421$. It is probable that the value of p was not greater than 400 in these experiments. We have seen (equation 2, *ante*) that if v is the instantaneous potential difference of the condenser terminals, and i the current flowing into it at any instant, $i=C\frac{dv}{dt}$. Hence, on the assumption of a simple periodic variation of the current, we may write p for $\frac{d}{dt}$, and put as the value of the square root of the mean square of the condenser current, I, the expression,

$$I = p C V,$$

where C is the capacity, and V is the potential difference of the terminals of the condenser as read by an electrostatic or Cardew voltmeter. It then follows that the capacity of the cable is determinable from the values of the condenser current, I, the pressure, V, as read at the step-up end, and from the known value of p.

We may examine how far the capacity value so deduced agrees with measurement.

We tabulate in columns the values of the condenser currents, I, found from Table II., and set against these the mean potential difference of the inner and outer members of the cable as the mean potential difference of the surfaces of the condenser. Calling these last values V, we then calculate the capacity, C, in microfarads from the formula,

$$C=\frac{I}{pV}\times 10^6,$$

on the assumption that $p = 400$. These results are set down in Table III. The values of the potential, V, are the means of the pressures given in columns V. and VII. of Table I. as the pressures at the step-up and step-down end of the trunk main.

Table III.

Condenser Currents, I, in Amperes, taken from Table II.	Mean Potential Difference of Condenser Surfaces, V, of Cable, in Volts.	Calculated Capacity for the whole Length of Cable, in Microfarads.
12·2	9,005	3·4
14·4	9,935	3·6
15·5	10,210	3·8
12·2	9,020	3·4
14·4	9,635	3·7
13·1	9,440	3·5

The mean electrostatic capacity of the 11·5 statute miles of the cable in use is, therefore, about 3·6 microfarads, as deduced from these experiments. On the day following these experiments the electrostatic capacity was measured at Deptford by Mr. H. R. Kempe, using a microfarad standard and a battery of about 18 Daniell cells, and taking galvanometer throw observations in the usual way. Mr. Kempe found the capacity under these circumstances of the respective mains to be about 1·98 and 2·02 microfarads, or in all about four microfarads. Accordingly, we see that the capacity, as deduced from the mean calculated condenser currents and the observed pressures at the ends of the mains, comes out a little low compared with the measured steady value; but the speeds and pressures were hardly observed with sufficient accuracy to make a closer agreement very likely, and the condenser current values are probably affected by some errors. It may be observed that the effect of a small but definite inductance in the fine-wire circuit of the transformers at the step-up end existing unannulled at full load would be to lower the condenser currents, and hence to lower the calculated capacity. I think it is pretty clear that what may be called the normal condenser current of the 11·5 statute miles of the trunk mains is about 14 or 16 amperes under a working pressure of 10,000 volts at the step-up end of the main, and at a frequency of about 67 for the circuit. This is what is generally observed.

On one occasion, when the writer was engaged with Mr. Ferranti in testing the trunk mains, we had a similar arrangement of the system to that above described—viz., a length of 11·5 statute miles of trunk main looped in London through two step-down and step-up transformers in parallel, and a similar set of transformers at Deptford.

Two 100 c.p. lamps were put on the far end of the system at Deptford, just to give indication of a current flowing through the system; otherwise there was no load. When the dynamos were excited so as to give 2,500 volts on the primary side of the step-up transformers, and this raised to 10,000 volts in the mains, we found a current of about 64 amperes going out of the dynamo at 2,500 volts. This would correspond to 16 amperes or so in the trunk mains. The actual working current at this time was merely the magnetising current of the step-down transformers and the normal current required for the lamps. Hence this experiment agreed in showing that the normal condenser current of the trunk mains at 10,000 volts pressure and a frequency of 67 is about 1·4 amperes per mile run of the cable.

19. Let us next examine how far the observations taken with no load on the secondaries of the step-down transformers agrees with the foregoing. In this case we restrict our view to the last eight observations recorded on Table I. The numbers in column IV. give us at once the condenser current of the cable, because there is no sensible current flowing out of the cable except the negligible magnetising current of the transformers.

Table IV.

Condenser Current, I, in Amperes.	Mean Potential Difference of Condenser Surfaces of the Cable, in Volts.	Calculated Capacity for the Whole Length, in Microfarads.
11	9,885	2·8
11	9,985	2·8
10	7,295	3·4
5	5,200	2·4
9	5,500	4·1
9	5,900	3·8
10	7,920	3·1
12	9,395	3·2

The variation in the values of the capacity shows that the measurements of the condenser currents are probably affected by considerable errors; and this is likely, seeing that the ammeters on the end of the trunk main would not read with sufficient accuracy to detect a difference of one or two amperes at these low readings. Hence all we can say is, that the mean capacity of the cable as deduced from the observations at no load—viz., 3·3 microfarads—is not extravagantly different from that obtained by observations at full load.

If we take one of the observations at half load—say No. 10 in Table I.—we arrive at the same result. For the ingoing and outgoing currents in the trunk main are then 22 and 17 amperes, and the difference of their squares is 14, which is probably nearly the condenser current in this case; and the mean potential difference of the surfaces of the cable is 10,560 volts; and hence, as before, the capacity comes out 3·3 microfarads for the whole length. Hence all the observations agree in giving a capacity of from 3·3 to 3·6 microfarads for the total cable in use. It may well be questioned whether for this paraffined-paper dielectric the capacity as

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determined by a prolonged charge and discharge gives a value which is correctly expressive of the true working capacity of the cable under rapid alternations of charge. It must be remembered that paraffined paper presents usually a considerable absorption effect, and the value of 4 microfarads for the 11·5 miles, obtained by the usual ballistic galvanometer method, may be, and perhaps is, a value which is higher than that which correctly expresses the true working capacity of the cable under rapidly reversed electric stresses. It is important to have this point investigated for the dielectrics in use in the manufacture of types of concentric cables now employed.

20. Passing to the examination of other points indicated by the observations in Table I., we see that the mean potential difference of the two conductors of the cable is always greater than four times the dynamo terminal pressure as given in column IV. That is to say, these figures show that the pressure in the trunk main at the dynamo end is always greater than would be the pressure at the terminals of the step-up transformers if the trunk mains were disconnected. This may be said to be the fundamental phenomena which has been much dis-described and misunderstood. The values of the pressures as read at the dynamo terminals and at the two ends of the trunk mains show that whenever the system is loaded, and there is a fairly heavy load, there is a fall of pressure down the cable, as there should be; although the actual figures seem to show that this fall of pressure is not quite equal in value to the product of the values of the true resistance of the cable and the current flowing through it. Those cases in which the figures in Table I. seem to show a rise of pressure along the main cannot be accepted as representing the actual facts. When the cable is relieved of all working current, and only traversed by a condenser current, the figures show that the cable is either all at one pressure all along, or else that there may be a slight rise from the step-up end to the step-down end of the cable. I think, however, that there is no good evidence of this rise of pressure from end to end of the cable when not loaded with external load. The chief fact is that, whereas the step-up transformers would, if existing alone, raise the dynamo pressure fourfold, we find that when the cable is heavily loaded the mean potential difference of the conductors exceeds four times the dynamo terminal pressure by something like 5 per cent.; and, when the external load is removed, that excess pressure more nearly amounts to about 10 or 15 per cent.

The general fact is quite in accordance with the foregoing theory. When the step-up transformers are heavily loaded, the inductance of their secondary circuits is practically annulled or very much reduced; when they are lightly loaded, it is at once increased. We have seen, in discussing the clock-diagram of electromotive forces as applied to this condenser problem, that the increase in pressure which takes place is always an evidence of the presence of inductance in the charging circuit, and that this rise of pressure will augment with increase of inductance in the line or in the step-up transformer. We are unable to test how far the general rise of pressure is in accordance with the foregoing theory, because we have no means of measuring the true mean inductance of the secondary, or high-pressure, side of the step-up transformers. The presence of capacity in the line always keeps down the inductance of the transformer, because it compels a rather large current to flow into it from the dynamo, even when the work current flowing out of the cable is zero, or nothing more than the magnetising current of the step-down transformers.

21. In the foregoing paragraphs no attempt has been made to enter into a discussion of the physical *modus operandi* of these condenser effects. We can easily construct, as has been frequently done, mechanical analogies, in which the elastic yielding of a spring and the inertia of a heavy body take the place of the capacity and inductance in the electric system. It is possible, however, to overrate the value of this mechanical parallel. It is probable that the actual physical operations taking place to produce these electrical effects are not adequately represented by a mechanical simile in which the inertia-like aspect of self-induction is exclusively regarded, although, of course, such mental representations have their use. Too much hypothesis is often as bad as too little in seeking to connect together observed facts and fundamental principles. We may regard a condenser, when subjected to periodic currents, as a non-dissipative impedance, if the term may be allowed, having also a negative self-induction. A condenser allows a flux of electricity to take place backwards and forwards through its dielectric, and, as far as alternating currents are concerned, it may be said to have a conductivity for electricity.

A condenser of capacity C, when traversed by periodic condenser currents of frequency n, acts in any circuit as equivalent to an impedance of magnitude $\frac{1}{C\,p}$. It also acts as if it had a negative inductance equal to $\frac{1}{C\,p^2}$, p, as usual, standing for $2\pi n$. By a negative inductance $\frac{1}{C\,p^2}$ must be understood a power of nullifying positive inductance in a conductor in series with the condenser numerically to the amount of $\frac{1}{C\,p^2}$ henrys. Suppose, then, that a condenser of capacity C is placed in series with an inductive resistance L and resistance R, and a periodic potential difference equal to V_0 permitted to act on the two in series. The resultant inductance of the whole circuit is $L - \frac{1}{C\,p^2}$, and the resultant impedance is

$$\sqrt{R^2+\left(L-\frac{1}{C\,p^2}\right)^2 p^2}.$$

Hence the current through the condenser is equal to

$$\frac{V_0}{\sqrt{R^2+\left(L-\frac{1}{C\,p^2}\right)^2 p^2}}.$$

If the potential difference of the two sides of the condenser is called V_1, and the equivalent impedance of the condenser is $\frac{1}{C\,p}$, we may consider that the value of V_1 is obtained by taking the product of this so-called impedance of the condenser, $\frac{1}{C\,p}$, and the value of the current flowing through it. Hence we have,

$$V_1 = \frac{V_0}{\sqrt{R^2+\left(L-\frac{1}{C\,p^2}\right)^2 p^2}} \frac{1}{C\,p};$$

but this is the same expression as that deduced before, for the ratio of V_1 and V_0. This is not to be considered as a demonstration of the equation, but only as showing how it may be regarded as being built up on the assumption that a condenser behaves towards alternating currents as an impedance causing fall of potential in a current passing through it, and capable of nullifying inductance in a circuit connected in series with it; and that such a view leads to an equation from which it is immediately seen that under some conditions V_1 must be greater than V_0.

(To be continued.)

SOME RESEARCHES IN ELECTRO-MAGNETIC INDUCTION.*

BY E. B. VIGNOLES.

(Concluded from page 51.)

I have entered into a lengthy and detailed description of the method employed, as it is novel, and presents very great advantages. I have thought it better to be too precise rather than not precise enough; for it is generally my experience that it is exactly the information you wish most to have which is omitted. For instance, in Dr. Hopkinson's classic Paper, the actual observations from which the curves are taken are not given, and from the scale of these the lower parts are difficult to trace.

In the following tables I give you the actual figures of some typical results.

The apparent increase in permeability is accounted for exactly by supposing the scale to have no permeability. Its removal decreases the area, and therefore increases the apparent **B**.

Note in the second curve, No. IIIa, the displacement of the curve with regard to the zero of magnetising force. We have not been able hitherto to account for this phenomenon satisfactorily. We have found it in several curves, the displacement being in some cases very large. It is perhaps due to a bias in the iron produced by a previous very high magnetising force in the direction of displacement.

This curve may be folded back to form the falling curve, as we have found that taking the falling curve by "breaking" methods gives too small an area, owing to causes which hardly come within the scope of this Paper.

I have given the falling curves obtained by carrying the iron through the cycle to the required point on the downward curve and then breaking P_2; but since taking them we have discovered the reason of their "humpbacked" appearance. In nearly every case, the falling curve comes down more perpendicularly than the rising curve, and for getting the hysteresis area more accurately it is best to fold over the rising curve. The iron cannot know which way round it is.

These curves only give an idea of the behaviour of cast iron. This material is very variable in its magnetic properties. Other specimens have given higher permeability.

* Paper read before the Old Students Association, May 13th, 1891.

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Table II.—*Magnet Bar Iron.*

Average length = 35 cm. Sectional area = ·877 sq. cm.

	Rising.		Falling.	
No.	H	B	H	B
1	- 39·5	- 15·55	43·3	15·8
2	- 29·6	- 15·1	38·5	15·4
3	- 19·75	- 14·5	28·6	15·05
4	- 9·9	- 13·4	19·75	14·4
5	- 0·4	- 7·75	9·9	13·2
6	+ 1·0	- 3·7	- 0·6	6·9
7	+ 3·0	+ 4·4	- 2·0	- 2·0
8	+ 9·9	+ 11·8	- 4·9	- 8·9
9	+ 20·7	+ 14·0	- 9·9	- 12·15
10	+ 29·6	+ 15·0	- 29·6	- 14·95
11	+ 39·5	+ 15·6	- 39·5	15·55
12	+ 48·3	+ 15·8		

Table IIa.—*Same Ring, Small Cycle.*

	Rising.		Falling.	
No.	H	B	H	B
1	- 2·0	- 7·7	5·0	8·5
2	+ 0·79	- 4·6	2·8	8·0
3	1·6	- 1·6	1·0	6·8
4	1·8	- 1·05	- 0·7	4·7
5	2·5	+ 2·7	- 1·2	2·7
6	2·3	4·0	- 1·6	- 0·1
7	3·7	6·5	- 2·0	- 3·0
8	5·0	8·2	- 3·5	- 7·0

Table III.—*Charcoal Iron, with Scale on.*

	Rising.		Falling.	
No.	H	B	H	B
1	- 48·3	- 15·2	55·1	15·2
2	- 40·2	- 15·0	12·7	13·2
3	- 21·8	- 14·3	4·6	11·6
4	- 4·6	- 12·5	0	9·0
5	- 0·6	- 10·9	- 1·9	- 0·4
6	+ 0	- 9·2	- 2·9	- 5·3
7	+ 2·9	- 0·2	- 6·9	- 10·6
8	6·9	+ 9·6	- 10·4	- 11·9
9	11·5	11·9	- 30·1	- 14·8
10	47·1	14·8		

Table IIIa.—*Same Ring, Scale removed by acid.*

	Rising.		Falling.	
No.	H	B	H	B
1	- 32·4	- 15·2	53·3	16·2
2	- 2·5	- 12·5	23·4	14·7
3	+ 2·0	- 8·0	9·0	12·6
4	+ 3·2	- 3·8	3·2	8·7
5	+ 4·4	+ 1·75	0·4	1·85
6	6·4	6·8	± 0	+ 0·6
7	8·3	9·9	- 1·2	- 5·1
8	12·4	12·1	- 3·7	- 9·8
9	18·2	13·5	- 8·6	- 12·6
10	31·9	14·8	- 22·2	- 14·5
11	56·0	15·8	- 39·9	- 15·2

Table IIIb.—*The same Material, another Ring. Average force-induction Curve, obtained by reversals, for High Magnetising Forces.*

No.	H	B	No.	H	B
1	10·0	12·0	6	96·0	15·9
2	20·0	13·4	7	110·0	16·0
3	39·8	14·4	8	132·0	16·4
4	61·2	15·1	9	158·0	16·6
5	84·0	15·6	10	179·0	16·9

Table IIIc.—*Charcoal Iron. Smaller Cycle.*

No.	H.	B.
1	- 3·81	- 6·7
2	- 1·77	- 6·3
3	- 0·41	- 5·86
4	+ 0·97	- 5·0
5	1·87	- 3·22
6	2·36	- 0·5
7	3·04	+ 2·4
8	3·72	4·6
9	4·42	6·3
10	4·6	6·65

Hysteresis loss: 4,650 ergs per cubic centimetre per cycle.

Table IIId.—*Same Ring.*

No.	H.	B.
1	- 9·0	- 10·3
2	- 5·16	- 10·0
3	- 0·8	- 9·1
4	+ 0·5	- 8·1
5	+ 1·4	- 7·1
6	+ 2·0	- 5·2
7	+ 3·0	- 0·2
8	+ 4·0	+ 3·9
9	+ 4·45	+ 5·0
10	+ 6·1	+ 8·2
11	+ 8·4	+ 10·1
12	+ 9·0	+ 10·3

Hysteresis loss: 9,930 ergs per cubic centimetre per cycle.

Table IV.—*Cast Iron.*

Average length = 32·6 cm. Area = 0·88 cm.

	Rising.		Falling.	
No.	H	B	H	B
1	- 32·3	- 5·4	43·7	5·7
2	- 24·5	- 5·1	33·2	5·3
3	- 15·7	- 4·6	24·9	4·75
4	- 6·6	- 3·97	16·6	4·3
5	- 1·7	- 3·36	8·3	3·66
6	+ 3·3	- 2·2	± 0	2·55
7	7·5	+ 0·5	- 8·3	- 1·0
8	10·4	+ 2·0	- 16·6	- 3·4
9	15·7	3·4	- 24·9	- 4·5
10	20·7	4·1	- 33·2	- 5·16
11	23·3	5·0		
12	37·3	5·44		
13	43·5	5·7		

Table IVa.—*Same Ring, Rising Curve for High Magnetising Forces.*

No.	H	B	No.	H	B
1	3·0	- 2·9	5	266	11·5
2	47	+ 6·4	6	353	12·3
3	91	8·4	7	596	13·9
4	178	10·3	8	662	14·6

Table V.—*Mild Cast Steel.*

Av. length = 43·3 cm.
Area = 1·156 sq. cm.

No.	H	B	No.	H	B
1	5·15	3·1	5	82·5	16·6
2	8·75	7·0	6	148	18·2
3	17·3	11·2	7	210	19·0
4	48·8	15·2	8	288	19·9

I will now give you the result of a test of a specimen of mild cast steel, from Langley Mills, Nottingham. Note that for large magnetising forces its permeability is nearly as great as wrought iron. The observations are by reversal method, as the hysteresis area was not required. The steel was not annealed.

Curve VI. shows the result of introducing air gaps amounting to $\frac{4}{1000}$ inch in a Lowmoor iron ring of 1·13 sq. cm. area, and 31·4 cm. long. It was obtained (the A curve) from a continuous ring, which was then sawn through, and the gap refilled by a piece of the same material, grain in the same direction. Thus treated the curve fell to B, a difference even at large induction densities of 5 per cent. or so.

Curve VII. exhibits in a comprehensive manner the results o the tests, taking average permeability, and as far as dynamos are concerned, these curves give all the information necessary.

The above curves embody practically every material which we have tested.

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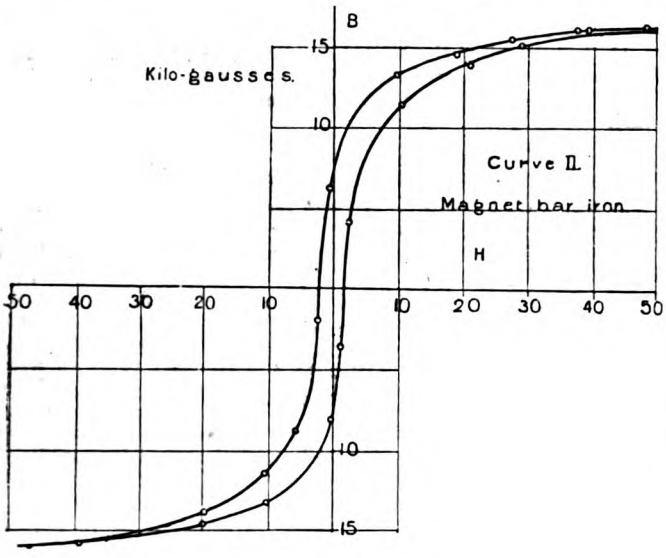
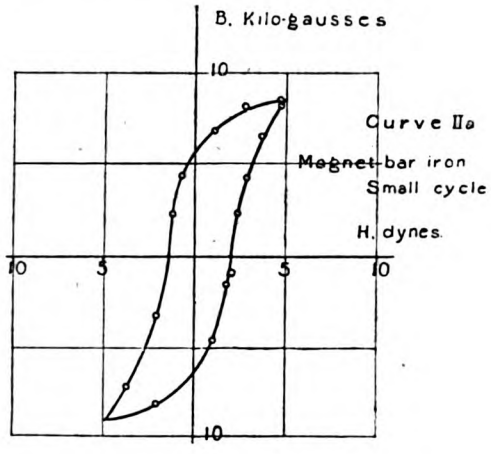
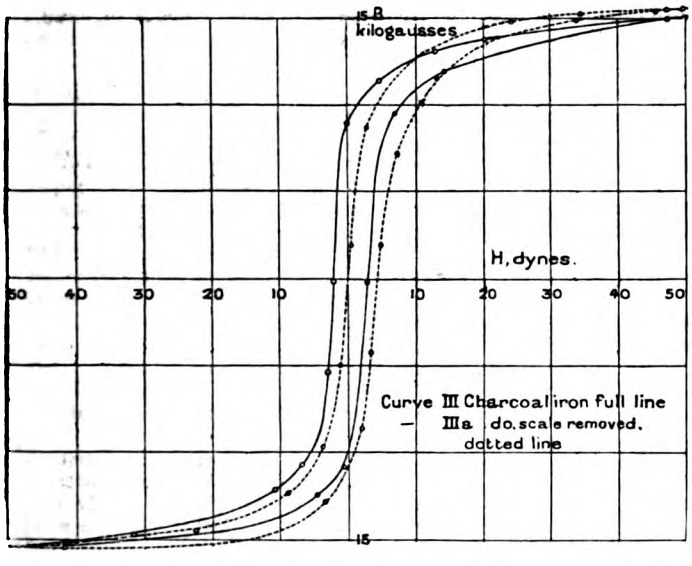
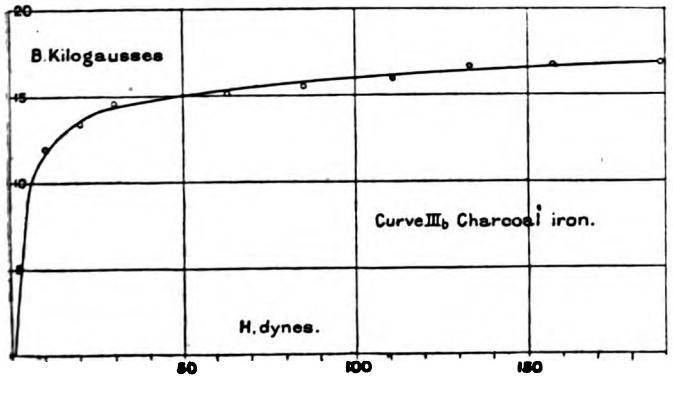
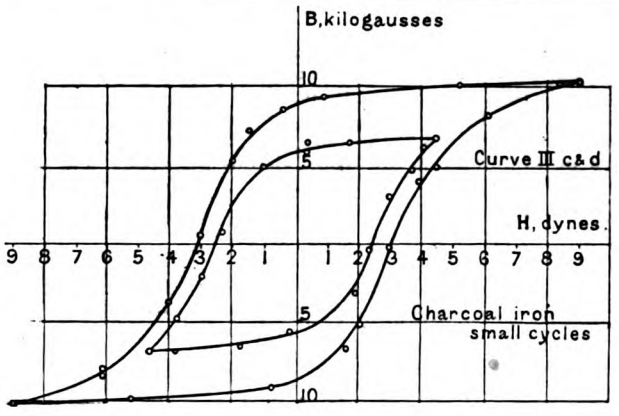


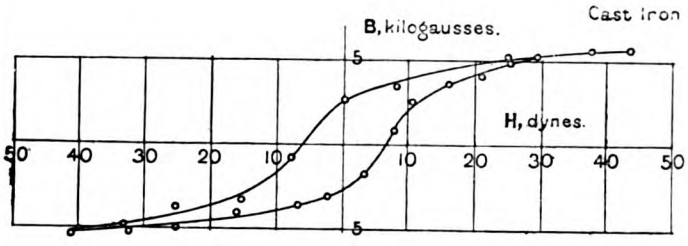


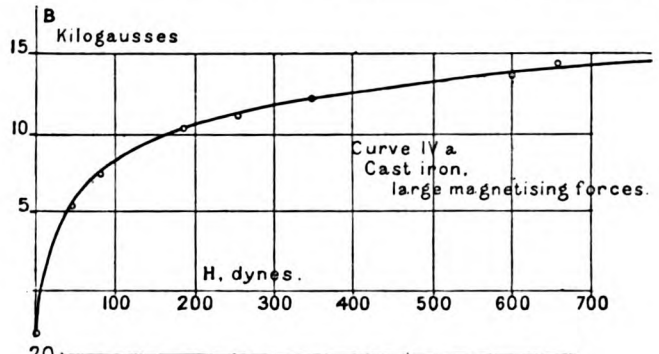


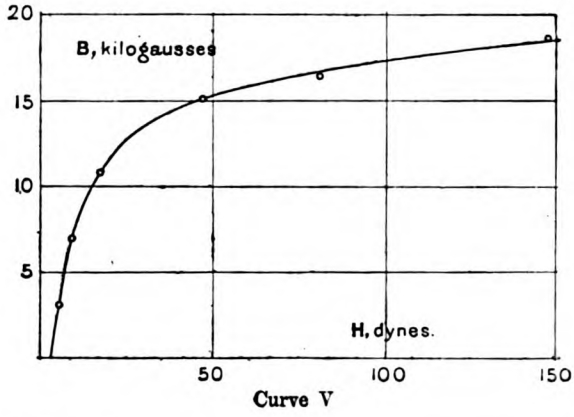




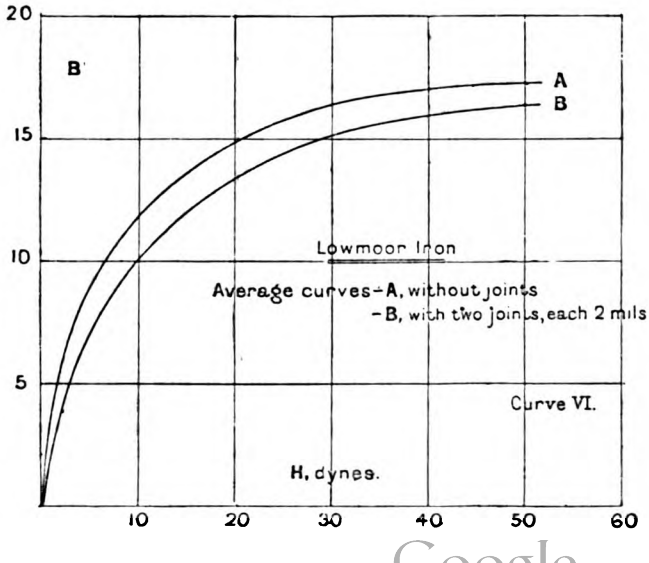
Curve IV
Cast iron







Curve V



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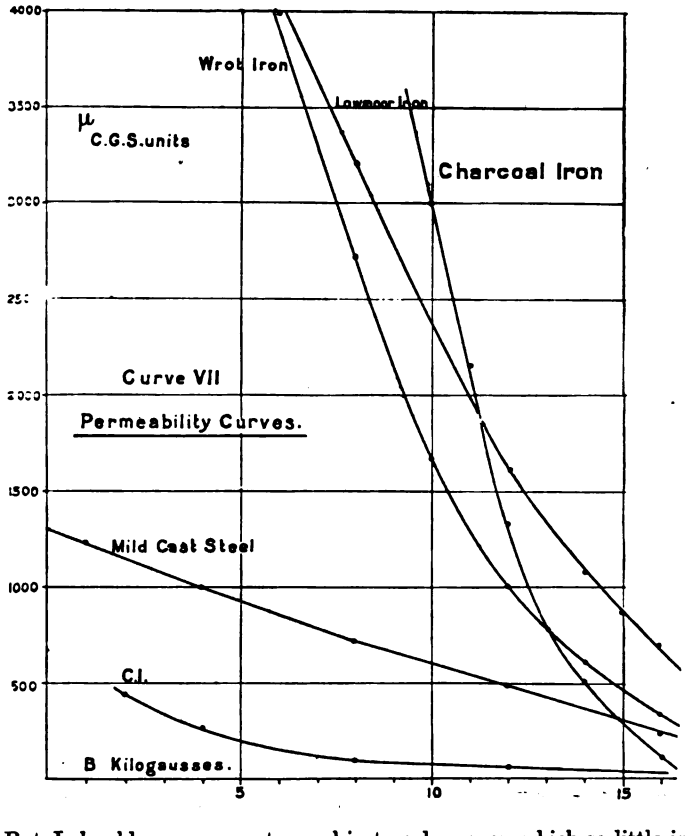
I could say much as to interesting side issues which have cropped up in the course of the research, but I have thought it best to keep strictly within the lines laid down at the commencement—a description of our method and the results obtained by it.

Even as I write this, I see the bearing of much of our work upon such vexed questions as the supposed "Mordey effect" (the decrease of hysteresis at full load), viscous hysteresis, and so on.



But I should open so vast a subject and one on which so little is known, if I were to be led off to these subjects, that I think these questions must be reserved, I hope for a future Paper.

At the same time I cannot help stating here, that some of the points brought out by these researches seem to us to have vital bearing on the subject of transformers, and also to a certain though less extent on that of dynamo armatures; and these points it will now be our business to further investigate.

[A full report of the discussion on this paper will appear in our next issue.]

ELECTRIC LIGHTING AT GLASGOW.

A Special Sub-Committee of the Glasgow Corporation has for some time past been engaged in considering what steps should be taken by the Municipality with regard to the carrying out of the powers entrusted to it under its electric lighting Provisional Order of last year. As already reported in these columns, the Sub-Committee, after receiving reports from Sir William Thomson, Mr. R. E. Crompton, and Prof. Jamieson, has recommended the Corporation to spend some £60,000 on an electric lighting scheme. We print this week the reports in question.

Sir William Thomson's Report.

1. For lighting the compulsory district, marked in the plan which accompanied your letter, the low-tension direct current system is, in my opinion, for many reasons decidedly preferable to the high-tension alternate current system with transformers, and is the system which ought to be adopted.

2. The method of distribution by feeders and distributing mains, patented by Edison for this country and America in 1882, ought to be adopted. It is adopted in the Kensington and Knightsbridge Lighting, and in the Westminster Electric Supply. I do not know whether any claim for patent right has been made upon them by Edison or his agents. The method, which is of great importance, was certainly described quite clearly by Edison in his patents. It seems probable that the question will be raised by Edison's representatives in this country when the result of litigation regarding it in the United States is known. I gave evidence in the American case, at the request of the Edison Company, and I think it right to point out to the Glasgow Corporation that there is at all events a possibility of a claim for royalty for the use of the system having to be met.

3. The supply station ought to be as near as may be to the district to be lighted. The nearer the better for good economy.

4. A moderate amount of storage battery should be provided, about enough, perhaps, to serve well for several hours at about 15 per cent. of the maximum ordinary rate of consumption. This would allow all the engines of the central station to be stopped, as a rule, every day from 4 a.m. till 8 a.m., and for a longer time, at all events in summer, if desired. The Howell-Crompton type is the best hitherto produced for the purpose of town lighting from central stations, because it is especially adapted to work with moderately good economy, and without damage to itself, for about one hour or somewhat more at an abnormally high rate of action, and so to meet a sudden demand, such as that entailed by a fog coming on suddenly, and to give fairly well the requisite supply of light until steam can be got up and the engines working from the central station at full power.

5. If the lighting was to be confined to the compulsory district alone, and a central station is provided, either within it or close to its boundary, the two-wire system would be preferable to the somewhat less simple three-wire system. But as large extensions to different parts of the town will no doubt be made, before long it is to be hoped, it would, I think, be right to begin at once with the three-wire system, with about 250 volts between the + and − mains, so as to be able to provide 110 volts for the houses.

6. In choosing a site for a central station, it is of great importance that there should be facilities, not only for carrying in coals but for carting away ashes, and as economically as possible, and with as little as possible of annoyance to the public.

Prof. Jamieson's Report. (Abstract).

The "*Direct Supply Low-Pressure System*" is both good and economical. But a slight variation in the speed of the engines instantly causes a corresponding variation in the light of the consumers' lamps. A complete stoppage, or even partial break-down, of the boilers or engines, or of the dynamos, &c., means a corresponding obliteration of the consumers' lights. The companies have to keep in readiness spare plant, so that it may be started at a moment's notice to replace any faulty corresponding portions. The mere act of putting this spare plant into gear, or even the addition or subtraction of an engine or dynamo, to those already in circuit is, as a rule, rendered clearly visible by a fluctuation of the light supplied to the public.

Combination of Dynamos with Storage Cells.—The liability to alteration or extinction of the lights is as far as possible at present avoided by the employment of storage cells. There are two practical well-tried methods. One of these is adopted at Kensington, and the other at Chelsea. Both of these methods employ tubulous boilers, generating steam at about 200lb. pressure on the square inch, to supply high-speed vertical compound engines, coupled direct to dynamos at the central station. Mr. Crompton conveys the outgoing current by means of the three-wire system of bare copper mains arranged in concrete culverts, to sub-stations where storage cells are kept. During the hours of small demand for current these batteries supply current at the required voltage.

The Electric Installation and Maintenance Company convey their current from their central stations at about 1,700 volts through underground mains to *one-half* of their sets of batteries at sub-stations in series. When this one-half has been fully charged, then the other half is automatically brought into circuit with the dynamos at the central station, whilst the fully charged set is automatically placed in direct circuit with the consumers' lamps. Only one attendant is employed at one time to periodically visit the sub-stations three or four times a day in order to see that things are going all right. But these automatic devices cost, at least, 10 per cent. of the whole outfit for the sub-stations, and consequently it is a matter for your consideration whether the advantages gained by the use of such devices and the disadvantages of their up-keep, compensate for the advantages gained by the more direct supply method employed by Mr. Crompton.

In the "*High-Pressure Alternate Current Transformer System*" of Mr. S. Z. de Ferranti, using 10,000 H.P. engines and an electrical pressure of 10,000 volts, there are immense possibilities as to the economical supply of electrical energy from a distant source of power. But this system, at such a high pressure, has scarcely had a sufficiently lengthy trial to warrant your recommending its adoption at present in Glasgow. Yet you have had working in the very centre of Glasgow for the last two years a central station, arranged upon the Ferranti system, with a lower voltage, viz., 2,400 volts, which has proved successful with overhead mains. These overhead mains will have to be replaced within two years by underground

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ones, by order of the Board of Trade. For high-pressure currents I have not met with any mains better than those devised by Mr. Ferranti.

Underground Electric Lighting and Power-Distributing Mains.—I have laid before you specimens of mains with prices. After very careful examination of the advantages and disadvantges of each kind, I am led to the conclusion that, for straight runs underneath the pavements of the streets, and for low-pressure supply, Crompton's concrete culverts, with bare insulated copper strip mains, are both the cheapest and the most elastic for extension. Where corners, crossings, and awkward bends have to be made then Siemens, or the India-rubber and Gutta-percha Company's best vulcanised india-rubber cables, drawn through pipes, or Callender's cables, may be used, as is found most convenient for each case.

Mr. R. E. Crompton's Report.

In accordance with your instructions I send you my report on electric lighting. These instructions were that I should prepare a scheme for lighting, by electricity, the streets in the compulsory, or what I hereafter call the central area.

Acting in strict accordance with your instructions, 1 first prepared a scheme for furnishing 5,000 16-candle lamps, lighted simultaneously in the central area from Partick. I prepared a second one for lighting the same area from Dalmarnock, but, as in both cases I find that the cost of the mains connecting the generating stations with the area was so great as to be disproportionate to the rest of the plant, I have prepared four other schemes with a view to ascertaining how far this cost of the mains can be reduced.

The object of working out these six schemes was to enable me to lay before you their comparative advantages and disadvantages, the capital expenditure likely to be incurred on each, and the cost of production of the electric light by each of the six schemes at varying scales of output. I have attached three sheets, marked A, B, and C, giving the result of my calculations. Sheet A is a tabular statement of capital expenditure. B is a tabular statement of what I call engine-room expenses—that is to say, the cost of working your plant within the engine-room. This portion of the cost, when calculated per unit, being pretty constant within wide limits of the scale of production; and C, the total cost of production, showing; 1st, the general charges; 2nd, the percentage charges for repairs, renewals, and interest on capital, all of which may be called fixed or standing charges, and which, when added to the engine-room expenses, give the total annual cost of production for any given output. I work this out in the case of the three partial schemes for 200,000 and 400,000 units per annum, and in the case of the three larger schemes, 200,000, 400,000, and 800,000 units per annum. In every case I have reduced the total cost of production into pence per net units sold, and these figures are entered in red, and are an accurate measure of the comparative merits of the six schemes.

In the first five of these schemes I have used the method of distribution that was applied by me successfully at Vienna, and is known as the five-wire system. I use continuous currents at 450 volts in combination with accumulators situated at several sub-stations. The pressure 450 volts is defined in the Board of Trade rules as a low pressure system, and is perfectly safe. This pressure extends only from the dynamo station up to the terminals of the accumulators in the sub-stations, which are led away to the houses at half this pressure and in the houses themselves at a quarter this pressure.

In Scheme No. 6 I do not even propose to use the 450 volts but the ordinary three-wire system that I am using in Kensington and our other London stations, the pressure in the charging mains being 240 volts, and in the houses 100 volts. In addition to the three important sheets, A, B, and C, I enclose sheets E, F, G, and H, which give in very full detail the method of working out the cost of the low-pressure network of conductors which distribute the electrical energy from the sub-stations to the consumers' houses. I may here remark that the cost of this portion of the system of electrical conductors, which it is convenient to call the network, is common to all systems of electrical supply, whether the systems be high or low pressure, as later experience in the use of the high pressure alternating current with transformers has shown that in future it is not safe or advisable to put the transformers in the consumers' houses, and that these high pressure systems must distribute from transformer sub-stations by means of a low pressure network.

Although my instructions related more particularly to Scheme 1, viz., that of supplying 5,000 16-candle lamps in the central area from Partick, yet as the result of my calculations show us very definitely that Scheme 6 is so greatly superior to the others that I think it will be most convenient for me to describe in full detail Scheme 6, and explain in what important points the other schemes differ from it.

Scheme 6.—Generating Central Station.—The Corporation to purchase land or pay ground rent for a site in a central position. The area required is about 550 square yards. I have allowed £5,000 as the cost of a substantial building of three floors, with a chimney of 130ft. high. On the ground floor will be placed a range of six boilers of the dry back marine type, each about 200 H.P.—that is to say, having 1,000 square feet of heating surface. On the same floor, arranged parallel to the boilers, I place on substantial foundations a row of five steam dynamos, each of 200 H.P. In addition to these I supply two small steam dynamos, each of 90 H.P. On the first floor, extending over the whole of the engine and boiler room, would be space for the home batteries of accumulators, and for stores and workshop. Over this can be placed rooms for the resident engineer in charge, and the offices.

Sub-Stations.—In Scheme 6 I only propose to put down one sub-station, to contain two batteries of accumulators. The space for these two batteries being small, and there being no machinery in motion to create a nuisance, it is usually an easy matter to find such a station in the "back" land, even close to a better class of property. One floor, 20ft. wide by 50ft. long, is ample for the purpose, provided it is strong enough to carry the weight, and is fairly well lighted and ventilated. The accumulators which I propose to employ were originally designed by Mr. Howell, of Llanelly, and have since been improved by myself. Four years' experience of their use in London have shown that the cost of up-keep of this class of accumulator is far less than had hitherto been supposed to be the case. Up to the present, the cost of repairs and renewals has not reached 10 per cent. of their first cost; but, in view of the possibility of heavy repairs to the plates being needed after six or seven years, I am in the habit, in all my calculations, of allowing a sum of 14½ per cent. per annum as the cost of the up-keep of these accumulators and their stands, and I believe this to be a perfectly safe and outside figure.

Distribution Plant.—If the local circumstances in Glasgow will admit of the use of the system of bare copper conductors strained in culverts, which I have applied with such success in London, I should strongly recommend it. In case, however, the local conditions at Glasgow are such that these culvert mains cannot be employed, I can use two other alternative methods of laying the conductors; one, that of drawing insulated cables into pipes laid in the streets; and the other that of using the patent bitumen trough system, invented and successfully employed by Messrs. Callender in Liverpool, Birmingham, and other towns.

My estimates are worked out on the supposition that three-quarters of the laying will be carried out on the culvert system, and one quarter on either the pipe or Callender system. The prices on which the cost of the culvert system has been worked out are obtained from actual experience in London, but we find that the cost in other towns, such as Northampton, is considerably less than in London, and it is possible that this may be the case in Glasgow. Whichever of the three systems, or if a combination of the three systems, is employed, in every case I propose to supply a large number of service boxes, or openings in the streets, at which ready access can be given to the conductors for the purpose of making the connections to the adjoining houses, or for repairing them, or withdrawing them and replacing them by others, in case this should be found necessary. All this can be done without further disturbance of the surface of the streets. I am strongly of opinion that such a provision is a necessary one in the case of electric lighting distribution plant, as it is impossible for anyone to say, with any degree of certainty, what number of houses facing the mains will eventually take the light. Actual experience in London has shown us that the attachment of the houses to the mains is a gradual process, and if it were necessary to open up the streets every time this is desired to be done, it would be an intolerable nuisance to the traffic, as well as spoiling the surface of the street. By my culvert system, combined with the pipe system above mentioned, I have succeeded in entirely avoiding this nuisance in London. Every alteration, or repair, or attachment that has been necessary during the four years the underground mains have been in use in the Kensington and Knightsbridge district, has been carried on at night without any disturbance whatever to the traffic of the streets.

Engine-room Expenses.—This portion of the cost of production can be estimated by us engineers with great certainty. After the consumption has once passed a certain comparatively low limit, the fuel, water, and petty stores used is almost directly proportional to the output in electrical units. The cost, however, of the labour item is greatly reduced as the output is increased, and will, I believe, be reduced to more than I have shown it in my table. I have assumed coke at Dalmarnock, 2s. 6d., per ton; Partick, 4s. 3d.; and at the central station, 5s. The cost of water at 4d. per 1,000 gallons is also assumed, but you will see that a slight variation in these two assumed prices will not materially affect the result. I have assumed the evaporative efficiency of the coke at 5½lb. of water evaporated per lb. of coke. A very small advantage is gained in reduction of engine-room expenses by placing your central station at Dalmarnock, the point at which fuel is cheapest. On the smaller scale of production, the difference is only ·15 of a penny, and the larger scale of production only ·16d.

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I have said nothing about the price to be charged for electrical energy, as I do not know whether the Corporation wish to make a profit on the sale of electricity or not; but there is a reasonable certainty that, at the scale I have shown, the electricity can be produced at the figures shown, and that the cost of the works will be as estimated. You will see in my estimated cost of the contract works, Sheet A, I have added an item of 10 per cent. for engineer's fees, drawings, and superintendence. This may appear somewhat excessive; but in this case, as throughout these estimates, I have given what I believe to be a safe figure. Moreover, as doubtless, if these works are carried out by your Corporation, the work will be done gradually, the cost of the engineering and superintendence will become somewhat higher than it would be if the work was given out in one contract and carried out in a year or so.

Capital Cost of Works.

	5,000 Lights, from Partick.	11,000 Lights, from Central Station.
GENERATING PLANT—		
Building, chimney, foundations, &c.	£5,000 0 0	£5,000 0 0
Boilers, each of 1,000 sq. ft. heating surface, at £581 fixed	1,743 0 0	3,486 0 0
Steam dynamos, 90 I.H.P., at £850 fixed	1,700 0 0	1,700 0 0
Steam dynamos, 200 I.H.P., at £1,610 each fixed	3,220 0 0	8,050 0 0
Steam and exhaust pipes, feed pumps, tanks, &c., at 35s. per I.H.P.	1,050 0 0	2,100 0 0
Switchboards, instruments, &c.	1,000 0 0	1,500 0 0
Travelling crane	200 0 0	200 0 0
Sundries, spare parts, tools, &c.	1,000 0 0	1,600 0 0
	£14,913 0 0	£23,636 0 0
STORAGE—		
Accumulators at generating and sub-stations — Large cells at £25; small, at £5. 15s.	£6,880 0 0	£5,600 0 0
Switchboard, coupling-up, instruments	900 0 0	500 0 0
Alterations to building for sub-stations	1,000 0 0	750 0 0
	£8,780 0 0	£6,850 0 0
DISTRIBUTION—		
Culverts	£6,858 10 0	£8,872 5 0
Service boxes	541 0 0	876 0 0
Cost of copper, in network	965 0 0	2,280 0 0
Do. feeders	850 0 0	2,763 0 0
Do. charging mains	7,650 0 0	1,370 0 0
	£16,864 10 0	£16,161 5 0
TOTAL OF CONTRACT WORK	£40,557 10 0	£46,647 5 0
Engineer's fees, drawings, superintendence	4,050 0 0	4,660 0 0
TOTAL COST OF WORKS	£44,607 10 0	£51,307 5 0

Engine Room Expenses.

	5,000 Lights, from Partick.	11,000 Lights, from Central Station.
A.		
Fuel—Partick, coke .....4s. 3d.	£226 10 0	...
Bothwell-street .....5s. 0d.	...	£266 10 0
Oil waste, petty stores, at ·07d. per unit	58 6 0	58 6 0
Water, at 4d. per 1,000 gallons	23 0 0	23 0 0
Lighting engine-room, sundries, at ·025d.	20 16 0	20 16 0
Engine-room labour	375 0 0	375 0 0
	£703 12 0	£743 12 0
AT 200,000 UNITS OUTPUT, THE COST PER UNIT	·84d.	·89d.
B.		
Fuel—Partick	£453 0 0	...
Bothwell-street	...	£533 0 0
Oil waste, petty stores	116 12 0	116 12 0
Water	46 0 0	46 0 0
Lighting engine-room, &c.	20 16 0	20 16 0
Engine-room labour	470 0 0	470 0 0
	£1,106 8 0	£1,186 8 0
AT 400,000 UNITS OUTPUT, THE COST PER UNIT	·665d.	·71d.
C.		
Fuel—Bothwell-street	...	£1,066 0 0
Oil, waste, &c.	...	233 4 0
Water	...	92 0 0
Lighting engine-room, &c.	...	20 16 0
Engine-room labour	...	560 0 0
	...	£1,972 0 0
AT 800,000 UNITS OUTPUT, THE COST PER UNIT	...	·59d.

Total Cost of Production.

	5,000 Lights, from Partick.	11,000 Lights, from Central Station.
SALARIES	£500 0 0	£700 0 0
Ground rents of station and sub-station	300 0 0	400 0 0
Insurance	50 0 0	70 0 0
Law and office charges	250 0 0	300 0 0
	£1,100 0 0	£1,470 0 0
REPAIRS TO PLANT AND RENEWAL—		
Buildings, at 2½ per cent.	£150 0 0	£175 0 0
Boilers, Steam Dynamos—		
Switchboards, at 5 per cent.	490 13 0	851 16 0
Accumulators and stand, at 14½ p.c.	1,000 0 0	810 0 0
Culverts, &c.—		
Copper insulators, &c., at 1 pr. ct.	126 0 0	121 0 6
Iron pipes and cables, at 6 „	256 0 0	240 0 0
	£2,022 13 0	£2,197 16 0
INTEREST ON CAPITAL	1,580 0 0	1,800 0 0
Cost, exclusive of engine-room exs.	£4,702 13 0	£5,467 16 0
ENGINE ROOM EXPENSES.—A.	£703 12 0	£743 12 0
200,000 units	5,406 5 0	6,211 8 0
COST PER UNIT	6·5d.	7·4d.
ENGINE ROOM EXPENSES.—B.	£1,106 8 0	1,186 8 0
400,000 units	6,809 1 0	6,654 4 0
COST PER UNIT	4·1d.	4d.
ENGINE ROOM EXPENSES.—C.	...	£1,972 0 0
800,000 units	...	7,439 16 0
COST PER UNIT	...	2·25d.

Summary of Cost of Culverts, &c.

SUMMARY OF COST OF MAINS—	First scheme.	Sixth scheme.
Culverts	£6.858 10 0	£8,232 5 0
Copper in network	965 0 0	2,280 0 0
Feeders	850 0 0	2,763 0 0
Charging mains	7,650 0 0	685 0 0
Total	£16,323 10 0	£13,960 5 0
Error	.....	685 0 0
Correct total	.....	£14,645 5 0
With maximum load of	500 amperes	1,000 amperes
Loss in mains =	11·25 per cent.	5·65 per cent.
Inc. cost due to 1½d. rise in copper	£1,125 0 0	£682 0 0
Length of culvert for charging mains	3,475 yards	1,025 yards
„ „ network	3,685 „	8,245 „
Total	7,160 yards	9,270 yards
Cost of service boxes—in mains	£174 0 0	£51 0 0
„ in network	367 0 0	825 0 0
Total	£541 0 0	£876 0 0

THE DIELECTRIC CONSTANT OF MICA.*

BY E. BOUTY.

In my experiments on well constructed mica condensers (Carpentier microfarad) I proved † that their capacity varies but little with the duration of charging, even for instance if it is reduced to $\frac{1}{500}$th of a second. I gave, moreover, a formula for calculating these variations or *residual charges* by two observations of each of the two capacities to be utilised. M. Carpentier having kindly placed at my disposal the mica sheets employed by him, I tried to find out whether it was possible to completely characterise their dielectric properties by the aid of one or more constants. The investigation on the standard condensers had shown that the variation of capacity between ·1 second and 1 second is, as a rule, less than $\frac{1}{200}$th; but it still remained to be ascertained if between the same limits and to the same degree of approximation, we could attribute an invariable dielectric constant to mica; that is to say, if the capacity of a sheet of surface S and thickness e is faithfully represented by the formula

$$e = \frac{k\,S}{4\pi e}$$

with a constant value for k. The thickness e was always less than ·01 cm. and S was always more than 50 sq. cm. With the degree of approximation obtainable, it was superfluous to have recourse to the artifice of the guard-ring. The measurements were made by a

* *Comptes Rendus*, Vol. CXII. No. 17. † *Ibid*, Vol. CX., p. 1,362.

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very simple method based on the employment of the capillary electrometer of M. Lippmann, and of an auxiliary microfarad condenser; it was an immediate outcome of the method employed by me in measuring residual charges.*

The sheets to be tested were first of all silvered by the Martin process. The silver was eroded from the edges by nitric acid, and by repeated washing and drying the free surface was deprived as thoroughly as possible of all trace of electrolyte. Finally, the edges were varnished with shellac and the condenser dried at a temperature of 140°C. The following values of k were obtained :—

S Sq. cm.	e μ†	k
49·50	14·75	7·91
65·34	29.09	8·00
65·11	34·88	
66·41	50·75	7·91
64·15	89·00	8·09
	Mean value ...	7·98

In a direction normal to the plane of cleavage *mica therefore possesses a well-defined dielectric constant*, for which the figure 8 may be adopted. It will be noticed that this number is more than three times the square of the mean index of mica, and that from what has been said before, the deviation would diminish but slightly if the duration of the charging period were reduced to $\frac{1}{500}$th of a second.

If it is sought to determine the dielectric constant of mica with sheets of tinfoil, very discordant and far too small values are obtained for k. Moreover, the capacity is considerably augmented when weights are applied. These effects are due to the presence of an irregular layer of air between the tin and the air. If we suppose this double layer of air to have an average thickness of only 5 μ, it is equivalent to a layer of mica eight times as thick,‡ and its presence reduces by one-half the apparent dielectric constant of a sheet of mica 40 μ thick. It is only necessary to establish continuity between the mica and the tin by the interposition of a drop of distilled water or of absolute alcohol§ in order to recover the normal dielectric constant.

With regard to residual charges, there did not appear to me to be any specific difference between the sheets tested. But for the same silvered sheet the residual charge varied so enormously with the condition of the unmetallised superficial layer that it is impossible to be absolutely certain on this point. For instance, it was sufficient on several occasions to wash well in water and then dry for 10 minutes at 140°C. to reduce to one-quarter the residual charge of a sheet which had already been kept for several hours at this temperature. *The incontestable origin of large residual charges is the electrolysis of foreign bodies situated in the superficial layer.*

By repeated attempts I always succeeded in reducing the residual charge formed by charges of two seconds and five minutes duration to values varying from $\frac{1}{60}$th to $\frac{1}{100}$th of the principal charge; that is to say, about one half the residual furnished by the different subdivisions of the Carpentier microfarad condenser which I investigated previously.

LEGAL INTELLIGENCE.

National Telephone Company v. Andrew Erskine Muirhead.

In the Court of Session at Edinburgh, on Wednesday, proof was heard before Lord Kyllachy, in an action by the United Telephone Company and the National Telephone Company, Oxford-court, Cannon-street, London, against Andrew Erskine Muirhead, merchant, Cart Forge, Crossmyloof, Glasgow, for the purpose of having the defender interdicted from infringing the pursuers' telephone patents, ordained to pay £500 damages, and ordained to deliver up for destruction all instruments that infringed the pursuers' patents. In his answers, the defender admitted that he had, with the knowledge and approval of the pursuers, used "Ader" transmitters and receivers for experimental purposes. The pursuers' averments were denied.

The pursuers were represented by Mr. Graham Murray and Mr. Dickson, and the defender by Mr. Asher, Q.C., and Mr. Watt.

Some days before the proof a minute was put in on behalf of the defender, in which he admitted having supplied to certain firms—Messrs. Merry and Cunningham and J. and P. Coats and John Chalmers—"Ader" and "Berthon" transmitters and "Ader" receivers; that these were supplied for the purposes of experiment during the currency of the pursuers' patents; that the "Ader" and "Berthon" were practically the same; that the sale of the "Ader" or "Berthon" transmitters was an infringement of the pursuers' second patent (the carbon transmitter), and that the sale of the "Ader" receiver prior to December 9, 1890, was an infringement of the pursuers' first patent (the magnetic receiver).

This left for proof only the question of whether instruments were supplied for experimental purposes, and, if so, whether this constituted an infringement of the patents; and also the question of damages.

On Tuesday evening the defender, in respect that one patent had expired, and that the other would expire in July, offered to consent to the pursuers' obtaining interdict; to deliver to them infringing instruments in his possession; and to pay £50 damages and expenses as between party and party.

Mr. GRAHAM MURRAY, in opening the case, said the legality of the pursuers' letters-patent was admitted by the defender. There was, therefore, no contest as to the instruments in question held by the defender being an infringement. The controversy arose through the defender saying that the instruments were supplied for experimental purposes, while the pursuers maintained that they were not for experimental purposes, in the ordinary sense of the words, and even if they were that would make no difference. The first witness called was

Mr. JOHN BREWIS, chartered accountant, Edinburgh, who deponed that, having examined the defender's books he found 87 telephones supplied before the date of the action. With the exception of two all these were supplied prior to December 9, 1890. In the ledger he found sums stated as having been paid for the instruments.

Cross-examined by Mr. ASHER: There was nothing in the entry to show that the money was received for Ader or Berthom receivers or transmitters.

SAMUEL THOMAS TURTLE, of Turtle and Appleton, Wandsworth, deposed that in 1890 he saw in the papers that the defender had some connection with long-distance telephones, and on September 8th he wrote to the defender, and found that he had telephones for sale. In the course of correspondence the defender made reference to the patent running out in December, and that if they had them fixed up before December there would be some risk in the matter. In reply, witness wrote that as their telephones were out of the way, and not likely to be seen by people, they did not mind running some little risk. On second thoughts they did not run the risk. Instruments were supplied, but he could not tell of what name they were. They were got in September, but they were not fitted up until after the patent had run out.

ADAM FERGUSON CLEMENTS, telegraph superintendent, North British Railway Company, deponed that in September, 1890, he received a circular and letter from the defender, asking to be allowed to send a couple of instruments for inspection. Witness replied that he had instruments from the Telephone Company, and it was no use the defender sending any. The defender pressed the matter, and ultimately he sent for trial, on 7th November, a pair of the cheapest Ader instruments, with two Poinery receivers and two Ader receivers. Afterwards, on 23rd December, he got a good many more. None of them were yet paid for.

Cross-examined: Their use was wholly experimental. He never understood that he had to pay for them. That was never in contemplation.

In reply to the Judge, counsel explained that up till 9th December, 1890, the Ader and Berthon telephones were infringements of the pursuers' patent. After that date the Ader receiver and magnetic transmitter were set free; the other parts, the Ader carbon transmitter and the Berthon transmitter and receiver, remained infringements up till July.

Mr. MURRAY said he might not be able to prove damage in one sense, but he might show that there had been much in another. The defender had ground-baited the trade in the whole country. He had gone to the railway companies with an instrument, and said that if they thought that would suit them the moment the patent expired they might give him a chance. He had no right to do that.

ROBERT MAIN, of Merry and Cunningham's, deponed that some telephones were supplied to the firm by the defender. They had been handed over to the Mr. Watson, of the Telephone Company, who replaced them by instruments of their own. The instruments were used for ordinary commercial work between the office and the works.

Cross-examined: They were first put up in July, 1890. He knew they were French instruments. A charge was made upon them after they were put down, some alterations being made upon bells. An account was rendered for them. The Telephone Company replaced them free of charge.

WM. HOWARD WINTERBOTHAM, the English solicitor of the pursuers, deponed that he had been engaged in the various litigations in connection with their patents. Early last year the defender communicated with the pursuers' Glasgow office as to certain French instruments, and suggested their being put into use. A correspondence ensued, in the course of which it transpired that the instruments imported from France by the defender were infringements of the pursuers' patents. Accordingly witness wrote him demanding that he should return them to France, or proceedings would be taken against him for infringement. The defender was anxious the pursuers should take up the French instruments. There was nothing new about them. After that correspondence, the defender did not send the instruments back to France, and the pursuers insisted upon them being sent to them. The defender delivered up some instruments, which the pursuers understood were the whole. They found afterwards that the defender was still advertising the instruments. In his circular the defender stated that he was selling the same instruments which were in operation between Marseilles and Paris. That, in witness's opinion, included the Edison transmitter, covering the "Ader" transmitter, the patent for which did not expire until July 30th this year. From witness's practical knowledge of the business, he considered that the sending of circulars by the defender to the railway companies was injurious to the pursuers' business. The profit on a set—a transmitter and a receiver—would be from £6 to £8

* *The Electrician*, Vol. XXV., Aug. 15, 1890, p. 415.

† μ = ·001 millimetre.

‡ It follows from this that in constructing standard condensers of tinfoil far more mica is employed than is necessary, which uselessly increases both their size and weight.

§ This experiment demands special precautions to prevent the electrolyte reaching the edges. It does not lend itself to accurate measurements.

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DANIEL SINCLAIR, manager of the pursuers' Company, said that the defender's proceedings in sending instruments to the railway companies was injurious to the pursuers. Before the expiry of the patent, the profit upon the sale of an instrument was from £7 to £8, and when it was let it brought a rent of £1 or £1. 10s. Altogether the Company had suffered damage of from £400 to £500.

Cross-examined: He did not know a customer of the pursuers who was induced to take telephones from the defender instead of from them, but in the case of Messrs. Coats, the fact that they were asked by the defender to buy telephones induced the pursuers to lower their rental for instruments. All over the rentals were reduced. It was the practice in this case to reduce the rentals on the approach of the expiry of the patents. They wished to keep on good terms with their customers, and reductions were made to persons who were not approached by the defender, and before this case arose. His estimate of damage was made upon the footing that customers, such as the Midland Railway, kept back orders until after the patent expired in consequence of the defender's proceedings.

Mr. GRAHAM MURRAY said that at luncheon-time a tender had been made by the defender. He had delayed accepting it until Mr. Winterbotham had had an opportunity of explaining in the witness box the cause of raising the action. Now, he thought it his duty to accept the tender, which was that the pursuers should get interest as craved, that they should receive any infringing instruments in the defender's possession, and that the defender should pay £50 damages and expenses as between party and party. He moved the Court to pronounce judgment in terms of the settlement.

Judgment was pronounced accordingly.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *May* 9, 1891.

Traction by Alkaline Accumulators.—The electrical sensation just now is a storage battery traction system that actually promises to lead to useful results. This statement may appear almost incredible, but experiments that have been in progress for something like a year, and a public trial in Philadelphia on Monday last, furnish good grounds for encouraging such a belief. The system in question is the invention of two New York electricians, Messrs. Waddell and Entz, and embodies several very excellent features. In the first place, the lead battery with all its concomitant disadvantages has been abandoned, and the motive power is furnished by 100 cells of the alkaline accumulator, similar to that introduced in France by Desmazures. During the early experimental period Messrs. Waddell and Entz met with considerable difficulty from the causes which damaged the reputation of the alkaline battery in France—the increase of resistance owing to oxidation of the copper and losses on open circuit. By furnishing the porous copper of the positive plate with a backing of dense copper, which is entirely unaffected during the operation of the cell, the resistance is kept down and the porosity of the copper is so great that there is not much chance for irreversible oxidation. The parchment paper envelope has been abandoned in favour of a textile covering that answers the same purposes and is less liable to deterioration. The result of these changes has been that the battery does not lose perceptibly on open circuit, and its resistance is very nearly constant. The liquid, of course, is caustic potash, and the negative plated perforated iron. The standard cells weigh 30lb., are 5in. by 7in. by 11in. in dimensions, and have an internal resistance of about ·001 of an ohm, the plates, of course, being in multiple. The electromotive force averages somewhere near ·8 of a volt, and a capacity of 800 ampere hours is claimed. Actual tests show the weight of the battery per electrical horse-power hour delivered to be between 55lb. and 60lb. The experiments tried in Philadelphia were on a line three miles long, with curves and grades as high as 5½ per cent. The car had operated with entire success over this line for some little time before the public trial, and makes an average speed, including stoppages, of about 10 miles per hour, with an expenditure at the power station of about one electrical horse-power hour per car mile. A part of these excellent results is due to the lightness of the entire car equipment, the batteries weighing 3,000lb. and the motor only 1,150lb. The motor possesses some peculiar characteristics of its own; its armature is a Gramme ring 21½in. in diameter, with internal field-magnets energised by a single magnetising coil along the axis of the machine; at each end of the core of this coil is a four-armed spider, with pole-pieces at the extremity, forming four north and four south poles alternating in position. The four brushes connect the armature in multiple arc. The motor is rated at 20 H.P., can be worked considerably above this, and has its point of maximum efficiency at an output of about 15 H.P.; at this point the commercial efficiency, without gearing, is 88·4 per cent.; at an output of 4 H.P. the efficiency is 80 per cent., and at 25 H.P. 86½ per cent. The machine thus has an excellent working range of efficiency, runs without sparking, and altogether is giving a very good account of itself. Its speed for 10 miles per hour car speed is about 450 revolutions per minute, and its armature pinion gears directly into the axle gear. The regulation is effected partly by changing the arrangement of the cells, and partly by cutting out part of the field coil. A switch is provided for throwing the motor into use as a charging dynamo when the car is running downhill, or when it is desired to bring it to rest. The cells of these cars are thrown into multiple series, and a certain amount of energy is restored to them; the inventors claim from ordinary roads something like 10 per cent. gained from this source. A more important advantage secured by this arrangement is the capital braking effect, either by stopping the car or graduating its motion down hill. Altogether, the experiments with this motor car leave one with the impression that it is at least a promising subject for further and more extensive trials. Currents as high as 300 amperes were used in the experiments, but the armature conductors are of ample cross-section and the heating was not at all severe. The total equipment, batteries and motor, is not heavier than the motors employed on the standard cars operated on the trolley system.

Transmitting Power from Niagara to Chicago.—One of the subjects under discussion with reference to the exposition to be held in Chicago is the possibility of transmitting power from Niagara Falls. The distance is about 500 miles, and, of course, alternating apparatus similar to that proposed for use at the Frankfort Exhibition would have to be used. With the advantage of the German experiment on a large scale, such an enterprise should not be unsuccessful if the expenses were not too heavy to be readily met. There will be no difficulty, probably, in securing the apparatus from the manufacturers, but the cost of line might be a formidable obstacle. The project is certainly worth looking into and will be discussed freely long before the time for executing it arrives.

Chicago Exhibition.—Everything with reference to the location of the electrical section of the Chicago Exhibition is as yet somewhat undecided. The plans of buildings which have been published recently may have to be entirely abandoned or very much modified, as the feeling now is that the electrical exhibits should be consolidated as far as possible, and not scattered as the architects' fancy would dictate.

BOOKS, &c., RECEIVED.

"City and Guilds of London Institute for the advancement of Technical Education.—Report to the Governors." April, 1891.

"Professional Papers of the Corps of Royal Engineers." Vol. XV., 1889. (Chatham: Royal Engineers' Institute.)

"The Rise and Extension of Submarine Telegraphy." By Willoughby Smith. (London: J. S. Virtue and Co.)

"Transactions of the Institution of Civil Engineers of Ireland." Vol. XX. (Dublin.)

"Proceedings of the Royal Society of Edinburgh.—Session 1890-91)." Vol. XVIII., pp. 1-64.

"Wire: Its Manufacture and Uses." By J. Bucknall Smith, C.E. (London: *Engineering*).

"The Journal of the Franklin Institute." Vol. CXXXI. No. 785. (Philadelphia: Franklin Institute).

"The Silvertown Patent Portable Testing Set." (London: Indiarubber, Gutta Percha, and Telegraph Works Company).

"Telegraphy." Preece and Sivewright. Ninth edition, revised and enlarged. (London: Longmans, Green and Co.)

"Journal of the Iron and Steel Institute." (London: E. and F. N. Spon.)

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CORRESPONDENCE.

ELECTRO-MAGNETIC INDUCTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In a note referring to my Paper on Magnetism in your current issue, you remark that our method of test could be improved, "as suggested by Prof. Ayrton," by winding the two magnetising coils on the same part of the ring.

I should be sorry if a false impression were created by your remark, and would therefore call your attention to the fact that, in my Paper, in reference to Fig. 1, I expressly state that the coils are *always* superposed.

What Prof. Ayrton said was, that if the *secondary* were wound under the primaries next the iron there would be no correction necessary for induction other than that in the iron. This is perfectly true; but, for practical reasons, it is more convenient to put the secondary outside; and the error is quite negligible until the permeability of the iron becomes comparable with that of air.

You also suggest imitating the load currents in a transformer by winding a coil carrying a heavy current like a non-inductive resistance round the iron; but wound thus, the coil would have absolutely no effect as regards the "B-H curve." Leakage is beside the question. It will vary with the design of each transformer, and cannot be taken account of in a general research such as ours.

When our researches leave *iron* and come to *transformers* the leakage question will become all important.

Dr. Sumpner has pointed out to me that I have used "dynes" erroneously as the C.G.S. unit of H. *What* it really is, no one has yet been able to inform me.

I should like here to express our indebtedness to Messrs. W. J. Goolden and Co., who very kindly put the resources of their factory at our disposal for the purposes of this research.—Yours, &c.,

ERNEST B. VIGNOLES.

Woodfield Works, Harrow-road, W.,
May 19, 1891.

TWISTED TELEPHONE LINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have pleasure in replying to Mr. Ullett's strictures on my letter of May 1st. If in doing so I have to trespass unduly on your space, I trust that the importance of the question to telephonists will be accepted as a sufficient excuse.

I confess that I regret the extension of the "twist" as being not only unnecessary but mischievous. No good engineer uses two bolts where one would suffice, and on the same principle telephonists should not construct perpetual aerial corkscrews where an occasional reversal answers just as well. The extension of the "twist," so far as the National Telephone Company is concerned, is not based on any question of comparative efficiency, but is due to the belief of the Directors that sooner or later their system will be taken over by the Post Office, and that a higher valuation will be placed on work executed in conformity with Post Office practice. In pursuance of this policy their staff were ordered early in 1890 to conform to Post Office ideas—or supposed ideas—in this and other particulars. I say "supposed ideas" because the Post Office do not adhere so rigidly to the "twist" as the National Directors imagine.

From the tenour of Mr. Ullett's criticisms I feel sure that he has had no experience whatever of the "cross," and that his ideas on the subject are not of the clearest. Otherwise he would not imagine difficulties where none exist, and base his arguments on the erroneous supposition that crossings must be both numerous and intricate. But taking his points seriatim:—

1. *Greater first cost of twist.*—The number of additional insulators, special brackets, and cross-connections required is very small. In erecting a loop, the two wires are run straight through, like ordinary telegraph wires. Afterwards the wires are cut, terminated, and crossed at the proper places. The cost of such a loop is not appreciably greater than two single wires run side by side. I could adduce instances to show that this is not the case with the "twist." The National Telephone Company keep very careful records of the cost of their trunk lines, and when I say that not only were the crossed trunks more efficient and cheaper to maintain, but invariably cheaper in first cost—in some instances ridiculously so—than the twisted ones, I am asserting that which is well within my knowledge, and is susceptible of proof by an inspection of the Company's accounts.

2. *Unsightliness of Twist.*—This Mr. Ullett admits, but says that it does not matter. I cannot agree with him. Telephone trunk lines have frequently to be carried past gentlemen's houses, and across estates. In such cases, as in dealing with road trustees and county councilmen, sightliness is of material moment, as any telephone manager who has to procure wayleaves knows.

3. *Greater Liability to Faults in Twist.*—As I stated in my former letter, I have never erected a twisted line. My experience—and it has been a bitter one—is derived entirely from having to exercise what patience was possible while sections of twisted trunk lines beyond my control remained interrupted for days together, and while subscribers were refusing to pay their subscriptions, and threatening to withdraw from the exchange in consequence of frequent breakdowns in the service. But I have often inspected twisted routes, and it seems reasonable to attribute, to some extent, the greater frequency of faults to the difficulty in regulating so as to maintain a constant vertical distance between the wires. On a model line, with equally-spaced posts of the same height, and wires regulated by the spring-balance, something approaching perfection could be attained, but where is the telephone trunk route to be found where such conditions obtain? Routes nearly always follow public roads, where equal spans are impossible, and where the poles may be anything between 28ft. and 60ft. high. Regulating on such a line is easy enough when one wire hangs exactly beneath another, and any neglect can be detected by the engineer as he walks along the road; but with the "twist" neither the man who pulls up nor the man on the road can do more than guess at what is being done, since the vertical distance between two crossing wires cannot be accurately judged from above or beneath. Variations of temperature destroy what symmetry there was to begin with, and so contacts occur. A notable instance of the disastrous effect of snow on twisted loops occurred a few years ago. A 50-mile route, made up of 25 miles of "twist" and 25 miles of "cross," was subjected to a heavy snow-storm throughout its whole length. On the "twist" section every loop was interrupted for several days, and it was weeks before even passable order was restored, for the whole had to be gone over and regulated. On the 25-mile section of "cross" there was not a fault of any kind. The copper wires had stretched with the weight of the snow, but their relative distances were unaltered, and no regulation was necessary. The dropping from a higher to a lower arm incidental to the twist is equivalent, so far as the strain on the wire at the upper insulator is concerned, to an increase in the length of the span. This does not matter much in ordinary weather, but with severe frost, adhesive snow, or heavy gale, it tells, and, according to my experience, very seriously. To make a twisted line equal in strength to a crossed one the spans must be shorter, which means extra poles and insulators, or the wires must be slacker, which means contacts. This 50-mile route belonged to the National Telephone Company, but a twisted loop 50 miles long leased to the same Company by the Post Office in 1883, was prolific of faults; indeed, for the first eight or nine months after erection, a week rarely passed without an interruption in spite of the specially anxious care of the linemen. In fact, it was the experience derived from this loop which first caused me to question the wisdom of twisting.

4. *Greater Difficulty in Finding Faults on Twist.*—My experience of prolonged interruptions on twisted sections has been extensive, and in such cases the engineers and linemen responsible always took refuge in the plea that faults were so difficult to find. Mr. Ullett says that a lineman has only to watch the

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apparent cross in the wires as he walkes along. This is virtually an admission of the difficulty which I say exists, for how can a man be expected to keep his eye with unflagging attention on a constantly moving cross for mile after mile? With one loop the effort must be considerable; with 12 or 14 loops on the same poles it would be arduous in the extreme. The London readers of *The Electrician* have an opportunity of judging for themselves just now by looking along Bartholomew-lane, either down from Threadneedle-street or up from Lothbury. Two twisted loops are suspended over Bartholomew-lane, and an apparent cross exists above that thoroughfare. Let the observer imagine 12 loops instead of two, and pity the man who has to follow such an arrangement, for 25 miles or so, over hill, dale, and housetops, with the sun in his eyes, perhaps, charged with the duty of separating real from apparent crosses. Besides, it is frequently impracticable for a man to follow a line exactly without trespassing and without great loss of time, and sometimes he will get a shady avenue or background of trees that will deprive him of the light necessary to trace his crosses. With straight wires a cross is noticed instinctively, because it is a break in the monotony of parallel lines. It may be seen from an express train, and under all circumstances is easier to find. Of course, the proper way to localise contacts is not by making men tramp the routes, but by testing from the stations; but that refinement for telephone companies is not yet.

5. *Re-arrangement of Routes.*—My statement was based on the experience of having a trunk route rendered next to useless for several weeks on and during a change from short to long cross-arms. The work was under the care of a great advocate of the "twist," and I felt bound to accept his assurance that the trouble was unavoidable. Nothing of the kind need happen with the "cross." So few crossing places are needed that their position may generally, for the time being, be ignored without detriment to the service. The re-arrangement is as simple as with single straight wires.

If Mr. Ullett, with whose position I have not the honour to be acquainted, has control of any telephonic system, and wishes to acquire actual experience of the "cross," I shall be happy to place drawings and full particulars at his disposal. He will find that much longer sections than 10 miles can be made so silent that any disturbance will have to be specially listened for; that crossed trunks of any length are electrically as good as twisted ones, and mechanically much better; in short, that twisted loops are as unnecessary as twisted lamp-posts. If Mr. Ullett specially objects to the cross-connections themselves, let him run his wires straight for several miles, and then devote a few spans to a corkscrew of orthodox fashion. That would be better than perpetual revolution.

With regard to Mr. Ullett's remark about two single wires on the same arm, I can only say that his experience has been different from my own, and would appear, at the same time, to have been singularly unfortunate.—Yours, &c.,

A. R. Bennett.

22, St. Alban's-road, Harlesden, N.W.,
May 18, 1891.

TRADE NOTES AND NOTICES.

Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.]

"THE ELECTRICIAN"

ELECTRICAL TRADES' DIRECTORY & HANDBOOK for 1891.

The 1891 edition of our well-known Directory and Handbook is ready, price 5s., postage extra. The book consists of over 900 pages, and has entailed this year a heavy amount of work. The Handbook Division contains a mass of most useful information. The Directory Division consists of 430 pages, and contains a very carefully compiled Alphabetical and Classified List of Firms and Persons engaged in the Electrical and Allied Trades in all parts of the world. This Division has been corrected up to date, and the book is thoroughly reliable, the very numerous changes which take place at the beginning of the year being incorporated. By the aid of this Directory, makers of Electrical Machinery, Apparatus, Instruments, Fittings, Sundries, Novelties, and other goods, may safely communicate direct with probable customers without the annoyance and great expense consequent upon using books which are mere lists of Members of Scientific Societies repeated again and again. The Colonial and Foreign Division of this Directory will be found extensive and reliable. *Orders should be forwarded at once.*

In the course of a few days "The Electrician" Company will publish "The Electrician" Primers in two volumes, price per volume 2s. paper covers, 2s. 6d. cloth.

Tenders Invited.—Particulars will be found in our advertisement columns of the request for tenders by the Gas Committee of the Manchester Corporation for lighting the Town Hall with electricity, reference to which was made in the Trade Notes in our last issue.

———. Tenders are required by the St. Pancras Vestry for supplying and erecting arc lights, columns for same, and road shelters, either together or separate. Copies of specifications, schedules and designs can be obtained at the office of Prof. Henry Robinson, C.E., the engineer to the Vestry, 13, Victoria-street, S.W., on and after to-morrow (Saturday), the 23rd inst.; and tenders are to be sent in to Mr. T. E. Gibb, the Vestry Clerk, Vestry Hall, Pancras-road, N.W., by June 1st. Particulars will be found in our advertisement columns.

Messrs. Oakden and Sharpe.—This firm notify us that they have added to their wholesale ironmongery business at Grimsby an electrical department.

Bristol's Recording Pressure Gauge.—This very simple and inexpensive instrument for giving a continuous record of the pressure in a boiler should be very useful in central station work. As there are no multiplying devices, it is not likely to get out of order. They are being supplied by Mr. J. W. Phillips.

Automatic Electric Railway Signal Company, Limited (in Liquidation).—A meeting will be held in the Small Sale Room, Exchange Station-buildings, Liverpool, on June 22nd, at 2:30, to receive an account of the winding-up.

Electric Company (Limited).—A meeting will be held at Messrs. J. Lord and Co.'s, 3, Bucklersbury, E.C., on June 18th, at 12, to receive an account of the winding-up,

Simplex Electrical Syndicate (Limited).— Resolutions were passed at a meeting held on April 22nd, and confirmed on May 7th, that this syndicate be voluntarily wound-up.

Woodhouse and Rawson Electric Supply Company of Great Britain (Limited).—Resolutions were passed at a meeting held on March 20th, and confirmed on April 17th, that this Company be voluntarily wound up, and that Messrs. Albert Hoster, T. H. Lambert, and F. L. Rawson be appointed liquidators.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

Note.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

April 27, 1891.

7,225. G. A. Nussbaum. London. Improvements in telephonic transmitters or microphones.

7,242. H. Bate. London. Electrically charged pills.

7,261. E. Dénorus. London. Improvements in and relating to the electro-deposition of metal upon fabrics, plants, animals, and the like.

April 28, 1891.

7,278. G. Percival. Cork. Improvements in electric switches and circuit closing and opening devices.

7,283. A. R. Bennett. London. An improved system of telegraphy and telephony.

7,292. H. Nehmer. London. An adhesive electrode for the application of electricity to animal bodies.

7,308. P. E. Singer. London. Improvements in musical instruments actuated by electricity.

7,315. M. W. Dewey. London. Improvements in method of and apparatus for electrically supplying hot water for consumption and heating purposes.

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331. C. D. ABEL. London. Improvements in telephones of the Ader system (Société Générale des Téléphones, Reseaux Téléphoniqu et Constructions Electriques, France).

W. P. THOMPSON. Liverpool. Improvements in and relating to dynamo-electric machines (F. Tischendörfer, United States).

April 29, 1891.

7,35 . J. P. BAYLY. London. Improvements in electric railway systems (D. G. Weems, United States).

5. E. ATKINS and W. ATKINS. Birmingham. Improvements in electrical fittings.

7,372. R. BOLTON and W. C. MOUNTAIN. London. Improvements in means or apparatus for actuating hammering, caulking, rock-boring, or like percussive machinery by the rid of electricity.

7,427. W. W. HORN. London. Improvements in electric time-locks (M. J. Flowers, J. E. Jones, and C. W. Price, United States).

7,433. Sir D. L. SALOMONS, Bart. London. A leakage detector or insulation tester, to be employed in the testing of electric lighting conductors and other leads.

7,434. A. NODON. London. Improvements in the electrolysis of chlorides, and in the utilisation of the liberated chlorine for the manufacture of chlorates, hypochlorites, and other compounds.

April 30, 1891.

7,479. E. E. KELLER. London. Improvements in underground conduits for electric railways.

7,493. E. A. SPERRY. Chicago. A system of mounting dynamos and motors upon rotary axles.

7 518. T. A. BULLOCK and A. C. BROWN. London. A new or improved combined transmitting and receiving sounder telegraph instrument or "Unigraph."

7,529. G. SHANN. London. A dynamo electric machine.

May 1, 1891.

7,531. A. CUTHBERT. London. An insulation cutter, or improvements in combination cutting pliers for insulated electric wires.

May 2, 1891.

7 596. F. NUSCH and S. NAWRATZKI. Liverpool. Improvements in or connected with telephones.

7,603. J. S. YULE and C. W. STEWART. Glasgow. Yule's electric signalling apparatus for passenger trains.

7,614. T. P. WALKER. London. Regulating the brilliancy of electric incandescent lights.

7,634. G. W. HUMPHREY. London. Improvements in electric alarm clocks.

May 4, 1891.

7,667. H. L. CALLENDAR. London. Improvements in dynamo-electric machines and electric motors.

7,688. A. SAUNDERS. London. A spiral filament for incandescent electric lamps.

7,697. C. P. ELIESON. London. Improvements in electrical accumulators or storage batteries.

7 699. H. J. ALLISON. London. Improvements in machines for making storage battery plates (P. Kennedy and C. J. Diss, United States).

7,700. H. J. ALLISON. London. Improvements in storage battery plates (P. Kennedy and C. J. Diss, United States).

7,701. H. J. ALLISON. London. An improved storage battery plate and method of making same (P. Kennedy and C. J. Diss, United States).

7,702. A. HOSTER. London. Improvements in or relating to the construction of electric lamp holders and other electric appliances.

May 5, 1891.

7,728. J. LEA. Northampton. Improvements in lamp-posts or columns for electric arc lighting.

7,755. H. H. LAKE. London. Improvements in and relating to electric motors or dynamo-electric machines (The Crocker-Wheeler Electric Motor Company, United States).

7,762. C. J. VAN DEPOELE. London. Improvements in reciprocating electric engines.

7,778. W. P. THOMPSON. Liverpool. Improvements in or connected with electric conductors (J. B. Williams, United States).

7,781. P. BOUCHEROT. London. A method or means for converting an electric current of constant periodic electromotive force into a current of constant intensity, and a current of constant intensity into one of constant difference of potential.

May 6 1891.

7,821. J. B. HAMILTON. Edinburgh. An improved machine for the conveyance of parcels and the like.

7,831. H. REYNIER. London. Improvements relating to the manufacture of insulating partitions for use in primary and secondary batteries.

7,850. W. W. HORN. London. Improvements in automatic telephone exchanges (A. B. Strowger, United States).

May 7, 1891.

7,857. F. BRYAN and WOODHOUSE AND RAWSON UNITED (LIMITED). London. Improvements in the construction of rheostats or similar electrical instruments.

7,858. C. S. SHELL and WOODHOUSE AND RAWSON UNITED (LIMITED). London. Improvements in switches used for electrical purposes.

7,863. R. B. HUTCHINSON, W. B. HUTCHINSON, and J. HUTCHINSON. London. An improved method of and means for cultivating land by the employment of an electric current.

7,878. F. J. ROWAN and W. MCWHIRTER. Glasgow. Improvements in appliances for preventing ignition of gases in connection with dynamos, motors, or other electrical apparatus.

7,911. G. S. GRIMSTON. London. An electric switch.

7,912. G. S. GRIMSTON. London. An electric capstan.

May 8, 1891.

7,937. C. W. COX. Liverpool. Improvements in or relating to electric resistance devices for measuring electric currents.

7,949. P. GOWARD. London. Improvements in secondary batteries.

7 954. G. POORE. London. Improvements in and relating to electric call apparatus.

7,960. R. D. SANDERS. London. Improvements in apparatus for use in the manufacture of metal tubes, cylinders, or other articles by electro-deposition.

7,970. E. A. WAHLSTRÖM. London. Improvements in distributing electric energy.

May 9, 1891.

7,976. G. BINSWANGER. London. Improvements in handles for electric light switches.

7,979. G. E. B. PRITCHETT. Stortford. Improvements in electric accumulators or secondary batteries.

8 009. G. POORE. London. Improvements in and relating to electric call apparatus.

8,031. H. HOWARD. London. Improvements in apparatus for heating and welding by the electric arc.

8,034. A. L. SHEPARD. London. An improved device for facilitating the connection and disconnection of electrical conductors.

SPECIFICATIONS PUBLISHED.

1890.

6,083. GORDON. Electric propulsion of tramcars. (Price 1s. 1d.)

6,726. VON HEFNER-ALTENECK. Electrical timepiece, &c. (Price 8d.)

7,981. SECHEHAYE. Dynamos, &c. (Price 11d.)

9,361. WILLSON. Electric reduction of metals. (Price 11d.)

15,274. BRIGHT and ENGELBACH. Electric lighting, &c. (Price 8d.)

18,180. FORBES. Primary batteries. (Price 11d.)

1891.

2,862. DEWEY. Electric fire engines. (Price 8d.)

3,349. DEWEY. Electric welding apparatus. (Price 8d.)

3,650. POPE. Electric motors for clocks, &c. (Price 8d.)

3,765. BUCHANAN. Electric arc lamps. (Price 8d.)

4,751. IMRAY (Wheeler and another). Electrical transportation systems. (Price 8d.)

4,758. CLARK (The Waddell-Ente Electric Company). Electric railways. (Price 8d.)

COMPANIES' MEETINGS & REPORTS.

The West Coast of America Telegraph Company (Limited).

The 14th Ordinary General Meeting of this Company was held on Friday, May 15, 1891, at Winchester House, Old Broad-street, the chair being occupied by Alfred Marshall, Esq.

The SECRETARY (Mr. Fred. L. Robinson) read the notice calling the meeting and the minutes of the last meeting.

The CHAIRMAN then said: With your permission we shall take the balance-sheet and report as read. The accounts which we present to you to-day give a very clear insight into the business which the Company has done during the year 1890, and, although it has not yielded as handsome returns as the year 1889, still the result must, as you will agree with me, be considered very satisfactory. The only item that calls for explanation is that of the gross earnings of the Company, which, although nearly the same as those of the year 1888, fall short of those for 1889 by about £20,000. This is to be accounted for by the repairing steamer earning

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about £5,400 less than in the previous year, owing to our neighbours having built and used their own steamer instead of employing ours as heretofore, and by our having earned much less on messages between Europe and the East Coast of South America, because there has been no repetition in 1890 of the interruptions that occurred on the Eastern lines during 1889, and which gave us such exceptionally large traffic receipts in that year. You will observe an increase of about £1,000 in the interest account; this is due to larger investments of the reserve fund. The negotiations referred to in the Directors' report are progressing favourably, and I have great confidence in their resulting soon in placing this Company in a firmer position than it was in before—to resist and cope with any competition that may arise. As these negotiations may entail the addition to our Board of one or two Directors, we have purposely not yet filled up the vacancy which occurred some time ago. If we cannot hold out hopes that the exceptionally large profit of 1889 will be repeated, we would ask you to bear in mind that in all telegraphic business one thing is certain, and that is, when an important distant community has once been accustomed to daily communication with Europe, it becomes an increasing necessity to them, and that, therefore, the total traffic with the West Coast of South America, may be looked upon as likely to increase, though, perhaps, suffering a temporary check from the present revolution in Chili—and that, consequently, we may expect the share of that traffic which we may secure likewise to increase. I am glad to be able to inform you that we received a few days ago, and since the issue of our report, the news that our cables were in working order from Lima as far south as Caldera, leaving only the most southern sections between Caldera and Valparaiso sealed by the Chilian authorities. Before putting the formal motion for the adoption of the report of the accounts, I shall be very glad to answer any question which any gentleman might have to ask; only, as regards the negotiations, my tongue is tied, as it would not be to the advantage of the shareholders that any premature information should be divulged with regard to them.

Mr. LAMONT inquired whether they were able to carry on business now to Europe in all the existing difficulties. He would not ask any question with regard to the negotiations, as he saw that it would not be advisable to do so.

The CHAIRMAN: Does any other gentleman wish to ask any question? After a pause, and no one rising to address the meeting, he continued: With regard to our present business since January 1st, we have been rather more fortunate than we could have expected. I think it was on January 15th when the revolution broke out, and the Chilian Government took possession of all the telegraph lines. They stopped our business for a time, but we received compensation from them. They paid us $15,000 for stopping our business, and then they made a contract with us to pay us $2,000 a day for the use of our wires and cables on the coast. This was a very handsome consideration. This contract came to an end on March 18th, so that we have been doing a very fair business—much better than could have been expected up to March 18th. Since then the most southern sections, we believe, have not been worked, but as the cables between Callao, Lima, and Caldera, are now in perfect working order, we are earning on them. I cannot tell you the exact amount that we have been earning since then, but I fancy it will pay our expenses from that time.

Mr. LAMONT: And our opponents' work.

The CHAIRMAN: Our opponents' cables are laid as far as Valparaiso. Their cable between Iquique and Valparaiso is not working, but they are working between Lima and Iquique. They are conveying any commercial messages that may arise between Iquique and Europe. It is only a fraction of the general traffic. Of course, all traffic from the other stations—from Mollendo, Arica, and Antofagasta, and so on—go over our lines.

A SHAREHOLDER said he thought that the reserve fund was a very handsome sum, and that all the shareholders would appreciate the prudence of the Board with regard to it. He thought, however, that it was customary in most companies to publish a list of their investments. He presumed that this was optional, but he thought as the amount was large that it would be satisfactory to the shareholders to see what it was invested in.

The CHAIRMAN: The investments are all made after consulting our auditors; but we will take into consideration the question of giving further details in future reports. I now formally propose

"That the report and accounts for the year ended December 31st, 1890, now presented, be received and adopted."

Mr. HENRY ROBERTS: I beg to second this.

The CHAIRMAN put the motion in the usual way, and it was carried unanimously. Continuing, he said: I have now to propose

"That a final dividend at the rate of 1 per cent. per annum, free of income tax, making 2½ per cent for the year, be now declared, payable on the 20th inst."

Mr. FREDERICK WALTERS seconded the resolution, which was carried unanimously.

On the motion of Mr. WALTERS, seconded by Mr. PACE, the retiring Directors, Mr. Alfred Marshall and Mr. Henry Roberts, were re-elected, as was also Mr. J. Weise, the retiring auditor, on the motion of Mr. PACE, seconded by Mr. TAYLOR.

Mr. WILLIAM PAYTON: Before we leave will you allow me to propose a vote of thanks to yourself for your conduct of our affairs? We hope that by your management we shall be in a better position in the future. If you are in the Chair on a future occasion I trust to see realised the hopes which you have given us to-day.

Mr. LAMONT: I have much pleasure in seconding the motion, and I congratulate you and the gentlemen on that side of the table on the more hopeful spirit you have evinced to-day than you showed when we last met together. I think that you were then under a cloud, and you seemed almost prepared to give up the fight. That, however, is not according to the British plan, and I am glad to see that you have exerted yourself, and that you are going to engage in the struggle, and are not going to be put down by any Yankee opposition.

The motion was carried unanimously.

The CHAIRMAN: I am very much obliged to you for re-electing me a Director, and for your kind expressions towards myself. I can assure you that I shall do my best; and, as I have to-day, I think, shown in my speech, I have much more confidence in the future than I could have had six months ago.

Mr. LAMONT said he hoped it would all be realised.

The CHAIRMAN: If anything important should happen for which your consent is required, it will, of course, be laid before you.

The proceedings then terminated.

Western Counties and South Wales Telephone Company (Limited).

The sixth annual ordinary general meeting of this Company was held on Saturday, at the Grand Hotel, Bristol, Mr. C. Nash (chairman) presiding.

The notice of meeting having been read by the General Manager and Secretary (Mr. H. F. Lewis),

The CHAIRMAN, in moving the adoption of the report and accounts, dealt with the question of capital expenditure, which, he said, in 1890 was £24,415, or £2,402 less than in 1889; but while the expenditure was less the rate of increase of the gross revenue was much larger. The advance in net revenue was still more striking, being the largest increase of any year in the history of the Company. The increase was £3,240, which was about 35 per cent. on the previous year's net revenue Then, again, the working expenses were over £400 less than the annual increase since 1885. With regard to their plant, not only had it been well kept up, but, as stated in the report, the substitution of the more durable and efficient copper-bronze wire had been extended. Many improvements had been made at various centres designed to give the subscribers the latest and best possible service. The balance, after paying interest on debentures and dividend on preference shares, would admit of a small dividend on the ordinary shares, but the Directors, after full consideration, had decided to advise carrying forward the balance of £2,677, after placing an additional £500 to the credit of the reserve fund, which would then amount to £2,200. The Chairman then spoke of the several points of the report bearing on the increase in the number of subscribers, the increase in wire mileage, and the increase of trunk messages, and contended that those facts pointed conclusively to the steady and continuous progress of the Company. Having alluded at length to their trunk system and its working, he said he hoped they would agree with him that the considerable outlay of £46,883 on trunk lines had been fully justified by the results. He found that between Cardiff, Newport, and Swansea there were in April 13,384 calls, and, as each call was answered, the total communications were 26,768, or more than 1,000 a day for the 26 working days of the month in that district alone. During the past year their trunk system had been extended *viâ* Gloucester and Worcester to Birmingham and the Midlands and the North of England. In the local exchanges he found that there was an increase of more than half a million calls in 1890 over 1889, and, as each call was answered, more than six million communications were made. Not only was the business continuous, but it was going on more rapidly than ever, and, considering the near expiration of patents and the rumours of competition, this fact was a striking proof of the firm hold the telephone had on the public mind. Eighteen weeks of the current year had passed, and in that time they had an increase of £1,845, against £1,504 in the corresponding period of last year, which showed a large weekly interest. Such continued and increasing advance was most satisfactory. There was another point, and that, he thought, was a very important one. The greater part of their agreements were for long periods, and had a considerable unexpired time to run. From a carefully-prepared table he found that at the end of last November they had 1,104 agreements for the year, and under 2,141 for periods ranging from one to nine years. Those unexpired periods of agreements represented on the 30th November last a contract rental to the amount of between £86,000 and £87,000, constituting an element of great stability for the Company. Those agreements had been secured by charging lower rates for the longer periods. They would agree with him that in case of a purchase by the Post Office or the National Company those long unexpired agreements, and the great general elasticity of their business, would constitute important elements of value. It only remained for him to state that one of their patents expired last December, and that the other would run out on the 31st July. That would relieve them from the payment of a considerable amount of royalty, and without committing themselves then in any precise figures, he might say that it was their intention to reduce the rates payable by their subscribers to at least the amount of the remission of the royalty, and they hoped that that reduction would lead to a considerable increase of business. This reduction would probably take effect from the 1st of August.

Mr. M. WHITWILL seconded the resolution, and said that the figures given by the Chairman showed conclusively that what they said years ago had proved to be true—that the business public were beginning to recognise the telephone as one of the necessities of existence.

In reply to a SHAREHOLDER, who asked why, seeing that there was enough money to do it, a dividend had not been declared on the ordinary

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shares, the CHAIRMAN said the local Directors did propose a small dividend, but on consulting the members of the Board in London the latter declined to sanction a dividend being made on the ordinary shares.

The report having been adopted, the CHAIRMAN then moved that a dividend at the rate of 6 per cent. on the preference capital be declared, which was seconded by Mr. FEDDEN, and carried unanimously.

The CHAIRMAN next moved that £500 be transferred from the balance to the reserve fund, which was seconded by Mr. POLE, and carried unanimously.

Mr. Charles Nash and Mr. R. Cory were re-elected Directors; and Messrs. Hudson Smith, Briggs, and Co., of Bristol, were re-appointed auditors.

The remuneration of the Directors was fixed at £600 for the ensuing year, and in acknowledging the same, the CHAIRMAN bore testimony to the excellent services rendered by the General Manager and Secretary, Mr. H. F. Lewis.

After the usual vote of thanks to the Chairman, the proceedings terminated.

Panulcillo Copper Company (Limited).

The 23th ordinary general meeting of the members of this Company was held on Thursday, at Winchester House, Old Broad-street, under the presidency of Sir John Pender, K.C.M.G., the Chairman of the Company.

The report stated that the operations at Panulcillo in the 12 months ended December 31, 1890, had resulted in a net profit of £7,037, of which £785 had been placed to the reserve, in accordance with the Articles of Association, leaving £6,252 to the credit of profit and loss account, which it was proposed to carry forward, the money being required to pay for the purchase of the Condesa Mine and other developments.

In proposing the adoption of the report and accounts, the CHAIRMAN said that when he last had the pleasure of addressing the shareholders, 12 months ago, it was just after the collapse of the great copper speculation, which caused a complete disorganisation of the copper market. He had, however, stated that, after careful consideration, the Directors thought that a much more satisfactory state of things would soon arise, and, although the growth might be slow, it was likely to be sure. This, more or less, had been realised, and the price of copper since then had advanced to a point which was likely to be maintained, and which was upon the whole a satisfactory price for Panulcillo. He also pointed out last year that the labour question was a serious one, as was also the difficulty of obtaining carbonate ores. All these questions were being solved now; labour was more abundant, and the Directors had secured an important carbonate mine (the Condesa), which was likely to prove very valuable. With a little further extension in this direction, they were looking forward altogether to a very much better state of things. The price of copper had remained satisfactory, and appeared likely to remain so, everything seeming to indicate that they might, for a considerable time at least, look on £50 as a probable, at least an average, price for Chili bars, while values would probably range somewhat above this figure, which was all they could desire. In briefly referring to the new markets for copper, he said that the other day, when he was addressing a large meeting of shareholders of the Metropolitan Electric Light Company, he had occasion to point out that during the 15 months of that Company's existence it had put down 90 miles of insulated copper wire; and when they looked at the large number of similar companies springing up, not only in London, but in every important town in this and other countries, it would give them some idea of the large quantity of copper that is being used, and will eventually be used, for electric lighting purposes.

The report and accounts were unanimously adopted, and the retiring Directors, Sir John Pender and Mr. F. Walters Bond, were re-elected.

The Consolidated Telephone Construction and Maintenance Company (Limited).

The following is the Directors' report to be presented at the tenth annual general meeting of the Company, to be held at the Cannon-street Hotel, E.C., on Thursday, the 28th inst., at 12 o'clock:—

The Directors have pleasure in submitting to the shareholders the report and accounts of the operations of the Company for the year ended March 31, 1891, the latter showing a net profit of £11,573. 8s. 9d., which, with the amount carried forward from last year, leaves a balance of £13,416. 6s. 8d. for disposal, after making provision for doubtful debts. The Directors propose to deal with this amount as follows, viz., to pay a further dividend of £7 per cent. for the half year on the ordinary shares, and £6 per cent. on the preference shares, making, with the interim dividend paid in November last, £6 per cent. for the year on both descriptions of shares; writing off the sum of £530. 3s. for depreciation of plant, machinery, and furniture, £63. 16s. 8d. from cost of new building, and the sum of £436 from goodwill and patent rights, thus leaving a balance of £1,716. 4s. 10d. to carry forward.

The lawsuit in Belgium, relating to the patents in which the Edison Gower-Bell Telephone Company is interested, is still in the hands of the solicitors, but it is hoped that a decision will soon be arrived at.

One of the patents for telephones held by the National Telephone Company expired on the 9th December last. This has had the effect of enabling the Consolidated Company to sell telephones to the public; and, so far as your Board can judge, an increasing business is in prospect. The shareholders may rely upon every effort being made to keep the Company's manufactures well in advance of both home and foreign competition.

The Subsidiary Companies continue to make most satisfactory progress, as is shown by the following statement:—

	Year ending March 31st.					
	Subscribers.		Rental.		Increase.	
	1890.	1891.	1890.	1891.	Subscribers	Rental.
			£	£		£
Telephone Company of Austria	2,868	3,263	18,100	20,500	395	2,400
Anglo-Portuguese Telephone Co....	1,915	2,074	12,232	13,458	159	1,226
Total increase for the year ...					554	3,626

In accordance with the Articles of Association, the following Directors retire by rotation, and, being eligible, offer themselves for re-election, viz., Sir Alexander Armstrong, K.C.B., &c., and Arthur Henry Baker, Esq. The Auditors, J. G. Griffiths, Esq., F.C.A. (Messrs. Deloitte, Dever, Griffiths, and Co.), and A. E. Green, Esq., F.S.A.A., also retire, and offer themselves for re-election.

NEW COMPANIES REGISTERED.

ART WORKSHOPS (LIMITED).—Registered with a capital of £30,000 in 1,100 guaranteed ordinary shares of £10 each and 19,000 ordinary shares of £1 each. Object: To acquire the business carried on at 58A, Brompton-road, 31, St. George's-place, and 5, Wilton-crescent-mews, Brompton, and to carry on the business (amongst others) of electrical engineers.

ALBION CLAY COMPANY (LIMITED).—Registered with a capital of £65,000 in £10 shares. Objects: To acquire the business of a brick and pipe manufactory, carried on under the title of the Albion Clay Company, at Woodville, Leicester, and to carry on the business (amongst others) of electrical engineers.

GEORGE CROSSLEY (LIMITED).—Registered with a capital of £15,000, in £5 shares. Object: to acquire the business of an engineer and iron-founder, carried on at the Albion Works, Cleckheaton, Yorkshire.

FOWLER INSULATOR SYNDICATE (LIMITED).—Registered with a capital of £6,000, in £1 shares (of which 500 are deferred), to adopt an agreement dated April 25, 1891, for the acquisition of the patent for "Insulators and Appliances for Suspending Wires or Aerial Telegraphs," and to manufacture the same.

REFRACTORY ORES REDUCTION COMPANY (LIMITED).—Registered with a capital of £30,000 in £1 shares. Object: To acquire certain patent rights, inventions, lands, estates and properties, and to carry on generally the business of metallurgists, miners, smelters, assayers, &c.

TOWNEND BROTHERS (LIMITED).—Registered with a capital of £25,000, in £1 shares. Object: to acquire the business of George Townend, of Payne's-lane, Coventry, and to carry on business as engineers, machinists, toolmakers, &c.

TREALAW ENGINEERING FOUNDRY COMPANY (LIMITED).—Registered with a capital of £10,000 in £10 shares. Object: To carry on business as mechanical engineers, brass and iron founders, and dealers in metal goods of every description.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the past week amounted to £5,176.

CITY AND SOUTH LONDON RAILWAY COMPANY.—The traffic receipts of this Company for the past week amounted to £665.

RUSTON, PROCTOR, AND COMPANY (LIMITED).—The Directors recommend a dividend for the past 12 months of 7½ per cent, with £1,049 to be carried forward.

SOCIETE ANONYME DES MINES ET FONDERIES DE ZINC DE LA VIEILLE MONTAGNE.—The report for 1890 of this Company, which has its seat at Angleur, near Liège, and has also zinc works in Germany, declares a dividend of 37½ per cent. The results for 1890 are the most satisfactory since the forming of the Company in 1837.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended May 15, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,170.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The receipts of this Company for the two weeks ended May 15th show a decrease of £154 as compared with the corresponding period.

WOODFIELD SYNDICATE (LIMITED).—This syndicate has been formed with the intention of carrying out some experiments on a large scale in connection with electricity, under the supervision of Messrs. W. T. Goolden and Co., without interfering with the manufacturing business carried on by them.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, May 13.		Price Wednesday, May 20.		Rate per Cent. Yielded	Dividend Due.	Business Done during Week ending May 20.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS.								
£1,381,380	Stock	12/0	Anglo-American	47	48	46½	47½	6 0 0	Jan., Apr., July, Oct	48*	47
£2,809,310	Stock	21/0	Do. Preferred	85	86	84	85	6 14 1	,, ,,	86½	85
£2,809,310	Stock	..	Do. Deferred	12	12½	11½	12	..	.. ..	12¼	11⅞
£250,000	100	4¾	African Direct, Telegraph 4½ Debentures	99	102	99	102	3 18 5	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	11⅞	12½	11⅞	12½	6 2 5	Mar., June, Oct., Dec.	12 1/16	11⅞
£84,500	£100	5¾	Do. 5 per Cent. Bonds	101	104	101	104	4 16 2	January and July ..	..	..
£75,000	£100	5¾	Do. 5 per Cent. Bonds (2nd Series, 1906)	104	108	104	108	4 12 7	June and December	..	..
$7,216,000	$100	7¾	Commercial Cable Capital Stock	108	110	108	110	6 7 3	April and October ..	..	..
16,000	10	8/0	Cuba Submarine	10½	11½	10½	11½	6 19 2	February and August	1 ⅝	..
6,000	10	10¾	Do. Preference 10¾	16½	17½	16½	17½	5 14 3	,, ,,	17	..
12,931	5	3/22½	Direct Spanish (£4 paid)	3½	4½	3½	4½	6 11 9	April and October..	..	..
6,000	5	10¾	Do. Preference 10¾	9	10	9	10	5 0 0	,, ,,	..	..
60,710	20	3/6	Direct United States	10¼	10½	10½	10½	6 13 4	Jan., Apr., July, Oct	10⅝	10½
400,000	10	2/6	Eastern	14⅜	14⅝	14⅜	14⅝	4 8 10	,, ,,	14 9/16	14⅜
70,000	10	6¾	Do. 6 per Cent. Preference	15¼	15⅝	15¼	15⅝	3 16 2	,, ,,	15⅝	15⅜
£1,200,000	Stock	6¾	Do. 4 per Cent. Mort. Debenture Stock	106	1 9	106	109	3 13 5	May and November	108¼	107½
£200,000	100	5¾	Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 10 11	February & August	..	..
250,000	10	6/6	Eastern Extension	14½	15¼	14½	15¼	4 13 4	Jan., Apr., July, Oct.	15 3/16	15
£320,000	£100	4¾	Do. 4 per Cent. Debenture Stock	105	108	105	108	3 14 1	.. ..	107	..
£91,800	100	5¾	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103	106	103	106	4 14 4	January and July ..	..	..
£145,300	100	5¾	Eastern & S. African 5 per Cent. Mor. Deb., 1900	103	106	103	106	4 14 4	,, ,,	..	..
180,227	10	2/6	Globe Telegraph and Trust	9¼	9½	9½	9¾	5 7 10	Jan., Apr., July, Oct.	9¼	9 5/16
180,042	10	6¾	Do. 6 per Cent. Preference	14½	15⅛	14⅝	15⅛	3 19 4	,, ,,	15 1/16	15
150,000	10	7/2	Great Northern	18¼	18⅝	17⅞	18⅛	4 11 11	Jan., April, and July	18⅛	18
£15,000	100	5¾	Do. 5 per Cent. Debentures, 1881	..	..	..	..	..	January and July ..	..	..
£230,000	100	5¾	Do. 5 per Cent. Debentures, 1883	105	108	105	108	4 12 7	March & September	..	..
17,000	25	12/6	Indo-European xd and Bonus	39	41	39	41	4 11 6	May and November	39	..
38,348	10	4.0	London Platino-Brazilian xd	6½	7½	6½	7½	6 0 0	,, ,,	..	..
£100,000	100	6¾	Do. 6 per Cent. Debentures	106	109	106	109	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's xd	8	8⅛	8	8⅛	4 14 1	April and October..	..	..
3,381	£100 Cert.	6¾	Submarine Cables Trust 6¾*	116	121	116	121	4 19 2	,, ,,	..	..
15,609	10	4/0	West African Telegraph	8	9	8	9	5 11 1	January and July ..	..	..
£230,900	100	5¾	Do. 5 per Cent. Debentures	97	100	96	99	5 1 0	March & September	96½	..
30,000	10	3/0	West Coast of America	3½	4	3½	4½	..	January and July ..	..	..
£150,000	100	8¾	Do. Debentures 8% 1902	97	102	100	105	7 12 5	June and December	..	..
88,321	10	9d.	West India and Panama	3½	3⅝	3	3½	..	.. ..	3⅝	..
34,563	10	6/0	Do. 1st Preference 6%	11½	12½	11½	12½	4 13 0	May and November	..	..
4,669	10	£3	Do. 6 p. c. 2nd Pref.	11½	12½	11½	12½	4 16 0	,, ,,	..	..
64,174	15	6/0	Western and Brazilian xd	11¼	11⅝	11	11½	6 10 7	,, ,,	11½	..
27,873	7½	6/0	Do. 5 per Cent. Cumulative Preferred xd	6½	7	6½	7	5 7 3	.. ..	6½	..
27,873	7½	4/6	Do. 5 per Cent. Deferred xd	4½	5½	4½	5½	..	.. ..	4⅛	4½
£210,000	100	6¾	Do. 6 per Cent. Debs., Series "A" 1910	103	106	103	106	5 13 2	February & August	..	..
£250,000	100	6¾	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103	106	103	106	5 13 2	,, ,,	..	..
$1,336,000	$1,000	7¾	Western Union 7 per Cent. 1st Mortgage xd	117	122	117	122	5 14 9	May and November	..	..
£175,100	£100	6¾	Do, 6 per Cent. Sterling Bond	100	104	100	104	5 15 5	March & September	..	..
			TELEPHONES.								
224,850	14/0	0/4½	Consolidated Telephone Const. & Maintenance	7/16	9/16	⅛	9/16	6 14 5	May and November	..	..
220,000	£1	4·76	Oriental (11s. paid) xd	¼	⅜	¼	⅜	5 2 11	Yearly	..	..
438,984	5	2/6	National	4⅛	4⅜	4⅛	4⅜	5 12 10	June and December	4 1/16	4⅛
15,000	10	6/0	Do. 6 per Cent. Cumulative 1st Pref.	12¾	13½	12¾	13½	4 10 11	,, ,,	..	..
15,000	10	4/9½	Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd)	12	12½	12	12½	3 16 10	,, ,,	..	..
..	£100	..	Do. Debenture Stk. 4½% Prov. Cert. (fully pd)	102	104	102	104	4 6 7	.. ..	104	103½
209,750	1	..	South of England, Ordinary	..	..	..	..	..	.. ..	..	..
20,000	5	..	Do. 6 per Cent. Cumulative Pf. (£3 10s. pd)	..	..	..	..	..	.. ..	..	..
58,000	5	1/0	United River Plate	2½	3½	2½	3½	..	January and July ..	..	..
£146,128	Stock	5¾	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 3	.. ..	..	..
£3,200	100	..	Do. 7 per Cent. Debentures	..	..	..	..	..	.. ..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
1,000	£50	..	City of London Electric Lighting Shares (£25 pd)	32	34	32	34	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	4½	5	4½	5	..	..	..	..
5,322	£5	3½%	House to House Electric	4⅜	5⅛	4⅜	5⅛	..	..	..	..
30,000	£5	..	Liverpool Electric Supply (£3 paid)	2⅝	2⅞	2⅝	2⅞	3 13 1	..	..	..
111,000	5	..	London Electric Supply	2⅛	2⅜	2⅛	2⅜	..	..	..	..
43,900	10/0	2/0	Metropolitan Electric Supply (£9 paid)	9	9⅛	9	9⅛	4 5 4	..	9⅛	..
7,730	£5	..	St. James' and Pall Mall	5⅞	6⅛	5⅞	6⅛	..	..	..	..
..	..	..	Do. 7% Preference	⅝	¾ prem.	⅝	¾	..	..	..	..
42,853	5	..	Westminster Electric Supply (£5 paid)	4¾	5¼	4¾	5¼	..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
63,416	3	..	Brush Electrical Engineering	2½	2⅝	2½	2⅝	..	..	2 1/16	2 1/16
63,416	2	1/1	Do. 6 per Cent. Preference	1⅝	1⅞	1⅝	1⅞	6 8 0	June and December	1⅞	1 11/16
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	4	5	4	5	7 0 0	January and July ..	..	..
17,130	5	..	Edison and Swan United	..	..	..	..	..	.. ..	..	..
45,000	10	6¾	Electric Construction	5	6	5	6	..	.. ..	5⅜	..
70,000	2	10/0	Elmore's Patent Copper Depositing	1½	2	2	2½	..	.. ..	2⅜	2 1/16
20,000	5	..	Fowler-Waring Cables (£4 paid)	2½	3½	2½	3½	..	.. ..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	18½	19½	18½	19½	5 2 7	February & August	19½	19¼
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	104	102	104	4 6 7	March & September	..	..
11,334	£10	6/1	International Okonite Limited Ordinary	7½	8½	7½	8½	11 15 3	.. ..	..	..
11,334	£10	5/0	Do. Preference	9½	9⅝	9½	9⅝	8 4 1	.. ..	..	..
78,949	5	4/10½	Swan United (£3. 10s. paid) xd	4½	5	4½	5	6 19 10	May and November	..	..
37,350	12	36/0	Telegraph Construction and Maintenance	45	47	46	48	..	March and July.....	46½	45½
£150,000	100	5¾	Do. 5 per Cent. Bonds, red. 1894	102	105	102	105	4 15 3	January and July ..	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£3 paid)	2⅝	2⅞	2⅜	2⅝	..	.. ..	..	..
..	£5	..	Do. Preference (fully paid)	3⅜	4⅛	3⅜	4⅛	..	.. ..	..	..
			RAILWAYS.								
50,000	£10	..	City and South London Railway	5	6	5	6	..	..	..	..

*Ex. £1 on account coupon 15th April, 1891.

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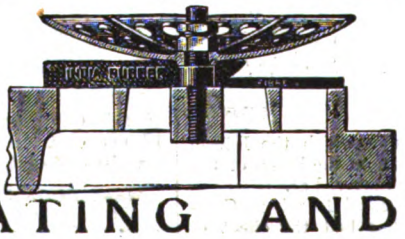

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"12, John-street, Sunderland, 26th Sept. 1885.

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 680.—Vol. XXVII. FRIDAY, MAY 29, 1891. Price Fourpence.

NOTES.

At the last meeting of the Institution of Electrical Engineers, Sir William Thomson recalled attention to the tendency of alternating currents to avoid the central portions of metallic conductors, thereby giving rise to an increase of resistance which has been occasionally alluded to under the name of the "skin effect." This phenomenon would be of great importance if currents of high frequency were in use, but, except with very heavy leads, the magnitude of this effect is of little moment with ordinary alternating currents. The alteration of resistance is only a few per cent. with leads of one centimetre in diameter, and as the whole loss in the leads is only a small fraction of the energy supplied, the diminution, owing to this cause, of the commercial efficiency of the installation is so small as to be rarely worth the expense of avoiding.

With low-tension work bare conductors can be used, and the effect diminished by making the section rectangular, instead of circular. With high-tension insulated conductors it is rarely necessary to use heavy leads, and even if this were the case it would, as Mr. Siemens pointed out, be inadvisable to make the conductor like a tube, for the increased size for the same section of copper would involve a greater expense in the insulating and protecting portions of the cable, and the interest on this extra cost would more than counterbalance the slight saving in economy. The practical importance of the effect has been over-estimated, and some of the remedies which have been proposed appear to be worse than useless. The mere stranding of the conductor does not obviate the difficulty if, as is usually the case, the inner strand is confined to the central portion of the wire; and any attempt at braiding the different strands, so that each one is sometimes within and sometimes outside the others, would be too costly to be worth while. Moreover, stranding the conductors produces an increase of resistance by itself, as the current has to progress spirally over a greater distance than the actual length of the stranded cable, and the extra resistance caused in this way may be as great as that due to the so-called skin effect.

Sir William Thomson probably surprised many of his audience by declaring such a decided preference for the low-tension direct-current system of supply, because it possesses greater simplicity than its alternate-current rivals. This quality must, doubtless, characterise any final engineering system, for only simple mechanical considerations and rule-of-thumb methods can permanently retain great importance. Electrical engineering, however, is not yet so stereotyped as the other branches of the industry, and direct-current systems have had a long start of alternate-current ones. In one respect the very complexity of the alternate-current system is an advantage, as it yields itself the more readily to new applications. It therefore seems too soon to forecast the future. Sir William Thomson's advocacy of the Edison system may encourage further litigation by Edison's representatives in this country; but as Prof. Kennedy points out in our correspondence columns this week, the Edison patent is not so far-reaching as it is imagined to be.

It must be confessed that, in spite of the amount of time which has been devoted to the action of transformers, the theory of them is still in a very unsatisfactory state. The assumptions which are usually made in describing their behaviour in mathematical language seem to be quite unjustifiable when closely examined. According to Mr. Evershed, two types of transformer exist, the real transformer which runs lamps, and the phantom which dwells in mathematical minds, and possesses constant coefficients, and an immaculate iron core. There appears to be nothing constant or certain about these strange members of the electrical family. The ratio of transformation not only varies to some extent as the load is changed, but may be altered very considerably by the use of condensers. Electrical engineers cannot yet be said to agree whether it is better to make their magnetic circuit closed or open, and the general confusion of the subject has been lately increased by the suggestion, based, it is true, on somewhat dubious experimental evidence, that the hysteresis loss in the core of a constant potential transformer diminishes as the load is increased. The latter phenomenon, if true, is of little commercial importance, as the diminution of the loss occurs when the need of getting rid of it is least; but it so revolutionises our notions of magnetism that the question of its existence is a most desirable one to settle as soon as possible, more especially as it seems to point out the possibility of getting rid of hysteresis losses altogether.

Some of the more important tests of transformer efficiency made in this country and in America have been carried out by means of Mr. Blakesley's split dynamometer method, and on the authority of some of these measurements is based the idea that the hysteresis losses alter with the load. The split dynamometer is, after all, only a modification of the ordinary wattmeter, with the advantage that no error is introduced owing

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to the self-induction of the coils; but the great fault of the method lies in the assumption that no magnetic leakage occurs in the transformer, and, in our opinion, this error is serious enough to invalidate the tests. At the last meeting of the Physical Society, however, Prof. PERRY directly challenged these views by endeavouring to show that the formula given by Mr. BLAKESLEY is true, even on the assumption that magnetic leakage occurs. To establish his point he proceeded to treat the transformer after the method of MAXWELL, assuming its coils to possess constant coefficients of self and mutual induction, and advanced the opinion that the abandonment of this method by HOPKINSON, who proposed to consider only the induction in the core and the current in the coils, was a move in the wrong direction. Although, no doubt, the simplicity of the latter method is very much diminished when leakage occurs in the transformer, and MAXWELL'S method renders it easy to take account of leakage by merely assuming less mutual induction between the coils, yet we think that if MAXWELL had lived longer he would have been the first to abandon his own method on finding the great variations which actually occur in his coefficients when iron is present in the cores. The Paper gave rise to a vigorous discussion, in which the balance of opinion appeared to be against Prof. PERRY. Mr. BLAKESLEY himself thought that there must be somewhere an error in the argument, and Dr. SUMPNER, Mr. SWINBURNE, and Prof. AYRTON also spoke against the method of proof.

AT the same meeting Prof. PERRY showed a new form of steam indicator which seems likely to be very useful. In the ordinary Richards indicator the vibrations of the cord introduce errors which become very noticeable at high speeds. This fault is entirely got rid of in Prof PERRY'S instrument, which has, moreover, the advantage that the diagram, instead of being traced by a pencil on an oscillating cylinder, is traced by a spot of light moving on a flat surface. The diagram can thus be seen while it is being drawn, and, if any change takes place in the action of the engine, an eye accustomed to indicator diagrams can at once detect what has happened. The apparatus is extremely simple; an ordinary galvanometer mirror being subjected to two rotary motions at right angles to one another, one caused by the motion of the piston in the cylinder, and the other by the pressure of the steam against a disc to which the mirror is attached. A common oil lamp gives enough light to produce a spot sufficiently bright to be seen in an ordinary engine-room, the whole arrangement can be set up permanently like an ordinary pressure-gauge, and with an engine running at a sufficiently high speed, the spot of light moves so fast that the entire diagram is continuously visible. The great advantages of this instrument for experimental work on engines are obvious, and in many cases it may prove of great value to have a permanent indicator attached to engines doing regular work.

THE electric light is as yet not nearly so important a rival of gas as the younger competitor, paraffin. DAVY observed the electric arc in 1802, and showed it on a fair scale in 1810. Two years after the invention of the Bunsen battery, in 1842, the electric light was publicly exhibited with a Foucault hand-regulated arc lamp. GREENER and STAITE patented their lamps in 1846 and 1847, and it was not until the latter year that YOUNG struck oil in Derbyshire. The supply ran out in three years, and his celebrated patent for extracting it from coal or shale was dated 1850. The American supplies were not utilised until 1856, by which time SERRIN had patented his highly developed arc lamp. Paraffin, however, quickly shot ahead, on account of the obvious simplicity of its use. Slight alterations in old lamps were soon made, and in spite of the dangerous properties of the imperfectly refined oil and the badly designed lamps, mineral oil became largely used. But the numerous accidents which attended both the handling and the consumption of it gave it a bad name—a name so bad, indeed, that petroleum is hardly ever mentioned. The name of one of the many distillates and residuals, and one which properly belongs to a wax discovered by REICHENBACH, in 1830, has been borrowed, and is commonly applied to it in this country, and, as with gelatin, it is customary to drop the final *e* in scientific literature. In America the name kerosine is given to the oil when freed from the dangerous benzines and other undesirable products.

THE proper construction of lamps for burning mineral oil has been carefully investigated by Sir FREDERICK ABEL, and most of his recommendations have been accepted by manufacturers of the better class of lamps. Very little information has transpired about the details of the lamentable accident which caused the death of three persons last week, but it seems that the lamp was upset, and thus set fire to the room. Another fatal accident occurred this week owing to the explosion of a lamp. Several mechanical devices of a somewhat clumsy appearance have been contrived to liberate an extinguisher in case a lamp is overturned, and it is probable that explosions caused by overheating of the burner could be prevented by a fuse which would act in the same way. With all these ingenious self-acting safety-devices, it may be possible to make the use of mineral oil no more dangerous than gas, but neither of these sources of illumination can ever compare with electric light in this respect. It is to be hoped that the remarkable use of oxygen as a restorative after suffocation, which is so graphically described in a recent number of the *Nineteenth Century*, will be speedily adopted. It would seem that the three lives lost on Saturday last might have been saved if it had been employed.

ON Tuesday last one of the *employés* at the Bourse office of the London-Paris Telephone line, having rung up the English end, took up the receivers and put them to his ears, with the unexpected result that he received a severe shock. The accident was probably due not to a direct lightning discharge, but to induction. The English land line is thoroughly protected by both plate protectors and vacuum tubes, and, beyond a few slight indications which were noticed before these were fitted, there has been no trouble at this end. The London-Paris wire differs, of course, from ordinary telegraph lines in that it is completely insulated from the earth, and any metallic circuit so insulated is liable to these static disturbances; but they have been seldom noticed before, probably because the circuits have not been of sufficient length.

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In another column we publish a draft memorandum on the preparation of the Clark cell. This has been drawn up for the consideration of the Electrical Standards Committee of the Board of Trade. The illustration which accompanies it is not official, but we have prepared it from the description, and believe that represents the type of cell used at the Cavendish Laboratory. Mr. GLAZEBROOK, to whom we are indebted for a copy of the memorandum, would be glad to hear the result of the experiences of any who may try to set up cells in accordance with these directions, that he may compare their results with his own.

THE somewhat stuffy atmosphere and comparative gloom of the City and South London Railway have a marked influence on the receipts whenever we are indulged with a little sunshine and warmth; indeed, a chart of this Company's weekly traffic returns would prove, at least, as accurate a record of the general state of the weather as a file of the daily prognostications of the Meteorological Office, the receipts falling as the barometer rises, and *vice versa*.

Telephonic Extensions in France.—The telephone trunk wire between Paris and Troyes (110 miles) was opened to the public on May 16th.

Appointment Vacant.—Applications are invited for the appointment of demonstrator of electrical engineering at the Yorkshire College, Leeds.

Commercial Cable Company.—This Company has opened an office in Cardiff, at 100, James-street, Bute Docks, with special wire service in connection with its cables.

Projected Application of Electric Traction in Berlin.—The engineer of the Grosse Berliner Tramway Company, Herr Fischer Dyck, has been sent to investigate the electric tramways in Budapest, with a view to the adoption of a similar system in Berlin.

National Telephone Company v. Andrew Erskine Muirhead.—Mr. Erskine Muirhead draws our attention to an error in the report of this action which appeared in our last issue, pp. 83-84. Mr. Muirhead states that he only agreed to pay £5 damages and costs, not £50.

Palermo Exhibition.—The electric lighting of this Exhibition has been secured by Messrs. Moleschott and Schilling, representing Siemens and Halske, of Berlin. Five 60 kilowatt machines are to be put down for the purpose, a sixth dynamo being used for running various motors throughout the building.

An Electric Light Carbon Trust.—Another step in the progress of the Carbon Trust was taken, says *Whipple's Reports*, of New York, early in the month, when the general offices of the Standard Carbon Company, of Cleveland, were removed to the National Carbon Company's building. The Carbon Trust is a reality, but thus far the projectors have not raised prices.

The Telephone in Chicago.—The Chicago Telephone Company contemplates the adoption of an improvement which will result in the disappearance of the magneto. If the proposed device comes into use it will only be necessary to place the telephone to the ear to ring up the exchange, the movement of the receiver-hook sending a signal to line. The proposed modification is estimated to effect a saving of some £8,000.

Barnet.—At the meeting of the Local Board, on the 5th inst., a discussion took place on the subject of the future lighting of the town. The Lighting Committee reported that no tenders had been received for electric lighting, and they recommended that offers be invited from persons willing to carry out any system—electricity, gas, oil, or even candles. A long discussion ensued; and ultimately it was decided that a deputation should wait on the Gas Company, and tenders be advertised for.

Cable Extensions.—The new cable (250 miles) connecting France and Corsica, which was manufactured at the Seyne Works, has been successfully laid by the "Charente."——The telegraph steamer Monarch arrived in Lerwick harbour on Friday afternoon last from Westray, Orkney, and immediately commenced laying a cable between Lerwick and the island of Brissay, a distance of about one mile. The work was completed the same evening.

Provisional Order Bills.—Mr. Campion, the examiner in the House of Commons, has found compliance with Standing Orders in the case of various Provisional Orders relating to the electric lighting of Edinburgh, Paisley, Preston, Liverpool (Toxteth Park), Birmingham, Cardiff, Scarborough, Torquay, Tunbridge Wells, Withington, Exeter, Ipswich, Newport (Mon.), Poole, Hertford, Bromley, Kingston-on-Thames, Weybridge, Camberwell, Islington, Southwark, Westminster, Wandsworth, Clerkenwell, Chelsea, and Woolwich.

Electric Rivetting Patents.—A decision has just been given by the Examiner of Interferences, in the United States Patent Office, in which priority of invention of the art of electric rivetting, and also of the apparatus for practising this art, was awarded to Mr. Elias E. Ries, of Baltimore, the other party to the interference being Prof. Elihu Thomson. The evidence showed that Mr. Ries was not only the first to file, but also the first to reduce the inventions to practice, and upon these and other facts brought out the decisions awarding priority to Mr. Ries were based.

Damage by Lightning.—A terrific thunderstorm broke over the western quarter of Dartmoor last week, and extended across the valleys of the Tamar and Tavy. At Tavistock cattle were killed and several trees struck. The Midlands were also visited by a storm of some severity. At Droitwich several trees were stripped, and at Nottingham the storm resulted in the ringing up of the fire brigade. At Alnwick, lightning struck the chimney of the armoury magazine and stores of the 3rd Northumberland Fusiliers, demolishing it and cracking the wall almost to the ground, notwithstanding that on a chimney-stack on the same roof there was a lightning conductor. On Wednesday, this week, a labourer working in a field at Ewerby, near Sleaford, was struck by lightning and killed.

Central London Railway.—The time has expired for lodging petitions in the House of Lords in opposition to the Central London Railway Bill, and only 10 petitions have been deposited. The petitions now deposited do not indicate any serious opposition to the preamble of the Bill. Four petitions are from owners of property who did not appear in the House of Commons, whilst the remaining six are from petitioners who lodged petitions in the House of Commons, but who, with the exception of the London County Council and Mr. Maurice Powell, a landowner, did not appear to support their petitions. The Commissioners of Sewers, who opposed this scheme in the House of Commons, have now presented a petition against any alteration being made in the Bill.

Paper Insulation for Electric Light Conductors.—One of the newest insulating materials, says the *Electrical World* of New York, is the paper insulation of the Norwich Insulated Wire Company. The wire is insulated with strips of the strongest manila paper, wound on in overlapping spirals. The paper is expressly made for the Company, and arrives at the works in rolls containing a web from half a mile to five miles in length, and weighing from 20 to 90lb. per ream. These rolls are cut into strips about half an inch wide and, perhaps, a mile long. After the wires are covered they are compounded with a material called "sydite." They are then braided, and again treated with a modification of the same compound, and are polished and reeled ready for the market.

A New Use for the Electric Light on Board Ship.—By the aid of the electric light, the Botanical Mission despatched some months since by the authorities of Kew to the West Indies were extricated from an embarrassing dilemma. They had with them a number of Wardian cases containing vine cuttings and Gambier plants, which it was deemed very desirable to introduce into the islands; but, unfortunately, cold weather set in, and the efforts to convey these tender plants, which had so often ended in failure, threatened once more to result in

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disappointment. The difficulty was that if kept on deck they would be inevitably destroyed by the low temperature; while if taken below the absence of light which is so necessary to the existence of the delicate Gambier plants was almost certain to be equally fatal. Under these circumstances it occurred to Mr. Morris to avail himself of the electric light, of which there was an installation on board the Atrato. The experiment proved in every way successful. Mr. Morris is of opinion that the use of the electric light for the safe passage of valuable plants during the winter months is capable of being greatly extended.

Frankfort Exhibition.—The catalogue of the Exhibition, compiled by Herr Alexander Askenasy, is a very creditable production. The first part (215 pages) contains a short *résumé* of the preliminary proceedings leading up to the Exhibition. Then comes a list of all the members of the Exhibition Committee and the names of the jury. This is followed by the catalogue proper, which gives each exhibit in alphabetical order, and indicates where it is to be found. Some idea of the trouble taken by the compiler may be gathered from the fact that there are 394 exhibitors, and that one firm alone has over 100 different numbers assigned to its goods. Some hundred more exhibits will have to be added when the Technical Department opens on June 15th. To the alphabetical list of 162 pages succeeds a numerical one, and this, again, is followed by a table of contents, so that visitors to the Exhibition will have three separate ways of tracing exhibits. By way of appendix is also given—(1) a description of the Exhibition workshops, (2) a description of the Exhibition lighting arrangements, (3) a description of the boilers, engines and dynamos, and (4) a ground-plan of the Exhibition.

The Jablochkoff Patent.—Another venerable patent, says *Industries*, has joined the majority. An attempt was made to galvanise it into life again, but its existence could not be prolonged beyond its allotted days. Little was known of this patent until recently, when it was suddenly brought forward to cover transformer distribution. The owners did not attempt to deal harshly with the public, and their moderation secured royalties instead of opposition. While the loss of the patent may be regretted from the owner's point of view, it may be as well to mention that Jablochkoff did not invent transformer distribution. Though his claim may have covered it, it was a mere accident. His object was not to transform from a high to a low pressure, nor to save copper in leads; but to allow a number of lamps to be run off one machine, or, in the words of those days, to "subdivide the electric light." He thought that by putting the lamps on secondary circuits of transformers in series, they might go out accidentally without destroying the continuity of the dynamo circuit. His transformer was specially designed to be short-circuited completely. He makes a merit of having the copper in metallic contact with the iron of the core throughout. We merely mention this as one of the too common cases where the merits of an invention are taken away from the real inventor and given to some earlier worker who has unintelligently stumbled on something like it, without in the least understanding its capabilites.

An Arc Lamp-Pole Device.—The need of trimming arc lamps daily first led to the use of a light, but sufficiently long, ladder, which the trimmer carried with him on his rounds. Later the upper rounds of this ladder were transferred to the poles, and the general adoption of the so called polesteps shortened the portable ladder, and threatened to stop its use altogether. As a substitute for this ladder a few detachable polesteps may be used, as they are much more easily carried about. Such a device has lately been put on the market, says a writer in the *Electrical Engineer* of New York, and reminds the writer of some home-made polesteps which he saw in use in an eastern town. It was at a place where the circuits spread out several miles in each direction, and many of the lamps were on the hills some 300 feet above the level of the rest. Such a topography made the carrying of the ladder quite a burden, and the ingenious trimmer soon hit on an easier plan. He drilled three holes into the sides of every pole at about the points where additional polesteps would be placed, slanting the holes slightly downward. Three short wooden pieces, whittled out of a broomstick, formed the steps for which these holes served as sockets. Then, with the wooden pegs hung from his tool-belt by little wire hooks, he started out on his rounds better equipped and yet less loaded down than before.

Institution of Civil Engineers.—At the annual general meeting of this Institution, on Tuesday last, the report of the Council for the Session 1890-91 was read, in which it was stated that an endeavour had been made to identify, in some degree, each gathering with a particular branch of engineering, both in respect to those invited to be present and to the models and other objects of interest exhibited. These receptions were believed to have been most successful, and experience would doubtless suggest directions in which they might be rendered still more useful and attractive in the future. Telford Medals and Telford Premiums have been awarded to Messrs. Ll. B. and C. W. Atkinson and to Mr. R. E. B. Crompton, and a Telford Premium to Mr. W. Langdon. The number of members of all classes, students excepted, on the 31st of March last was 5,150, as against 4,903 on the same day last year, representing an increase at the rate of 5 per cent. Adding the students to the number on the register, the gross total on the books was 6,064. From the balance-sheet appended to the report, it appeared that the receipts during the financial year amounted to £24,274. 8s. 11d. The Council congratulated the members that the House of Lords had upheld the judgment of the Court of Appeal, that the whole of the property of the Institution was exempt from duty, on the ground that it was legally appropriated and applied for the promotion of education and science. In conclusion, reference was made to the action of a committee of members outside the Council, which had resulted in the establishment of an endowment fund for the purpose of perpetuating the memory of the long services of the secretary in the interests of the Institution. It had been decided that the endowment in question, with any future additions, should be applied to the establishment of a "James Forrest Lectureship," it being left with the governing body for the time being to determine the subjects, the periods of recurrence, and all other details connected with such lectureship. The ballot for Council resulted in the election of Mr. George Berkley as president.

The Telephone in Paris.—The subscribers to the Paris Telephone Exchange, whose subscriptions date from a period previous to September 1, 1889, when the State took over the telephone system of the country, have recently been served with two somewhat unpleasant documents. The first, signed "J. de Selves,' runs as follows:—"By Article 5 of your agreement the various instruments composing your telephonic post and the accessories which you have asked for must be supplied by you and at your own expense. When the State took over the Paris system, the authorities allowed you the provisional enjoyment of the apparatus then in your possession. It is now necessary to set this matter right (*régulariser cette situation*). I have the honour to inform you that you will have to arrange with the Société Générale des Téléphones for the purchase of your instruments, from whom you will shortly receive the bill. This Company will be within its rights in taking away your instruments after a period of 15 days, and consequently your communication with the exchange would be suspended until further orders." This circular was soon followed by one from the Société Générale, enclosing the bill for the telephonic apparatus, and intimating that, unless payment was forthcoming within a fortnight, the apparatus would be taken away. Subscribers can, of course, if they prefer to do so, buy new instruments elsewhere; but these, if they contain an induction coil, will have been manufactured by the Société Générale, which, by a recent judgment (see *The Electrician*, Vol. XXVI., March 27, p. 632), has had its monopoly of this device when used in conjunction with the telephone confirmed. The situation is, therefore, somewhat curious; the State possesses a monopoly of the telephonic system of France, but the Société Générale possesses a monopoly of the apparatus. As the *Bulletin International de l'Electricité* remarks, it is a state of affairs which should have been foreseen, and subscribers should have been spared the inconveniences of it.

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ELECTROMAGNETIC THEORY.—X.

BY OLIVER HEAVISIDE.

(*Continued from page 783, Vol. XXVI.*)

§ 62. The two laws of circuitation did not start into full activity all at once. On the contrary, although they express the fundamental electromagnetic principles concerned in the most concise and clear manner, it was comparatively late in the history of electromagnetism that they became clearly recognised and explicitly formularised. We have not here, however, to do the work of the electrical Todhunter, but only to notice a few points of interest.

The first law had its first beginnings in the discovery of Oersted that the electric conflict acted in a revolving manner, and in the almost simultaneous remarkable investigations of Ampère. It did not, however, receive the above used form of expression. In fact, in the long series of investigations in electro-dynamics to which Oersted's discovery, and the work of Ampère, Henry, and Faraday, gave rise, it was customary to consider an element of a conduction current as generating a certain field of magnetic force. Natural as this course may have seemed, it was an unfortunate one, for it left the question of the closure of the current open; and it is quite easy to see now that this alone constituted a great hindrance to progress. But so far as closed currents are concerned, in a medium of uniform inductivity, this way of regarding the relation between current and magnetic force gives equivalent results to those obtained from the first law of circuitation in the limited form suitable to the circumstances stated.

If **C** is the density of conduction current at any place, the corresponding field of magnetic force is given by

$$\mathbf{H} = \frac{V\mathbf{C}\mathbf{r}_1}{4\pi r^2}, \quad \ldots\ldots\ldots \quad (1)$$

at distance r from the current-element **C**, if $\mathbf{r}_1$ be a unit vector along **r** from the element to the point where **H** is reckoned. The intensity of **H** thus follows the law of the inverse square of the distance along any radius vector proceeding from the current-element; but, in passing from one radius vector to another, we have to consider its inclination to the axis of the current by means of the factor $\sin\theta$ (where θ is the angle between **r** and the axis), involved in the vector product. Also, **H** is perpendicular to the plane containing **r** and the axis of the current-element, or the lines of **H** are circles about this axis.

But from the Maxwellian point of view this field of **H** is that corresponding to a certain circuital distribution of electric current, of which the current-element mentioned is only a part; this complete current being related to the current-element in the same way as the induction of an elementary magnet is to the intensity of magnetisation of the latter. Calling the complete system of electric current a rational current-element, it may be easily seen that in a circuital distribution of rational current-elements the external portion of the current disappears by mutual cancelling, and there is left only the circuital current made up of the elements in the older sense. We may, therefore, employ the formula (1) to calculate without ambiguity the magnetic force of any circuital distribution of current. This applies not merely to conduction current (which was all that the older electricians reckoned), but to electric current in the wider sense introduced by Maxwell. But the result will not be the real magnetic force unless the distribution of inductivity is uniform. When μ varies, we may regard the magnetic force of the current thus obtained as an impressed magnetic force, and then calculate what induction it sets up in the field of varying inductivity. This may be regarded as an independent problem.

In passing, we may remark that we can mount from magnetic current to electric force by a formula precisely similar to (1), but subject to similar reservations.

§ 63. But this method of mounting from current to magnetic force (or equivalent methods employing potentials) is quite unsuitable to the treatment of electromagnetic waves, and is then usually of a quite unpractical nature. Besides that, the function "electric current" is then often a quite subsidiary and unimportant quantity. It is the two fluxes, induction and displacement (or equivalently the two forces to correspond), that are important and significant; and if we wish to know the electric current (which may be quite a useless piece of information) we may derive it readily from the magnetic force by differentiation; the simplicity of the process being in striking contrast to that of the integrations by which we may mount from current to magnetic force.

To exemplify, consider the illustrations of plane and spherical electromagnetic waves of the simplest type given in §§ 53 to 61, and observe that whilst the results are rationally and simply describable in terms of the fluxes or forces, yet to describe in terms of electric current (and derive the rest from it) would introduce such complications and obscurities as would tend to anything but intelligibility.

Now, Maxwell made the first law of circuitation (not, however, in its complete form) practically the definition of electric current. This involves very important and far-reaching consequences. That it makes the electric current always circuital at once does away with a host of indeterminate and highly speculative problems relating to supposititious unclosed currents. It also necessitates the existence of electric current in perfect non-conductors or insulators. This has always been a stumbling-block to practicians who think themselves practical. But Maxwell's innovation was really the most practical improvement in electrical theory conceivable. The electric current in a nonconductor was the very thing wanted to coordinate electrostatics and electrokinetics, and consistently harmonise the equations of electromagnetism. It is the cardinal feature of Maxwell's system, and, when properly followed up, makes the insulating medium the true medium in the transmission of disturbances, and explains a multitude of phenomena that are inconceivable in any other theory (unless it be one of the same type). But let the theoretical recommendations (apart from modern experiments), which can only be appreciated after a pretty close study of theory, Maxwellian and otherwise, stand aside, and only let the tree be judged by its fruit. Is it not singular that there should be found people, the authors of works on Electricity, who are so intensely prejudiced against the Maxwellian view, which it would be quite natural not to appreciate from the theoretical standpoint, as to be apparently quite unable to recognise that the fruit has any good flavour or savour, but think it no better than Dead Sea fruit? The subject is quite sufficiently difficult to render understandable popularly, without the unnecessary obstruction evidenced by a carping and unreceptive spirit. The labours of many may be required before a satisfactory elementary presentation of the theory can be given. So much the more need, therefore, is there for the popular writer to recognise the profound significance of the remarkable experimental work of late years, a significance he appears to have so sadly missed. When that is done, then will be the time for an understanding of Maxwell's views. Let him have patience, and believe that it is not all speculative metaphysics because it is not to his present taste. Never mind the ether disturbances playing pranks with the planets. They can take care of themselves.

§ 64. Two or three changes I have made in Maxwell's form of the first circuital law. One is of a formal character, the introduction of the **h** term to express the intrinsic force of magnetisation. This somewhat simplifies the mathematics, and places the essential relations more clearly before the eye. Connected with this is a different reckoning of the energy of an intrinsic magnet, in order to get consistent results.

The second change, which is not merely one of a formal character, but is an extension of an obligatory character, is the introduction of the **h** term to represent the motional magnetic force. In general problems relating to electromagnetic waves it is equally important with the motional electric force.

The third change is the introduction (first done, I think, by Prof. Fitzgerald) of the term to explicitly represent the convection-current or electrification in motion as a part of the true current. Although Maxwell did not himself explicitly represent this, which was a remarkable oversight, he was strongly insistent upon the circuital nature of electric current, and would doubtless have seen the oversight the moment it was suggested to him. Now, there are spots on the sun, and I see

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no good reason why the many faults in Maxwell's treatise should be ignored. It is most objectionable to stereotype the work of a great man, apparently merely because it was so great an advance, and because of the great respect thereby induced. The remark applies generally; to the science of Quaternions, for instance, which, if I understand rightly, Prof. Tait would preserve in the form given to it by Hamilton. In application to Maxwell's theory, I am sure that it is in a measure to the recognition of the faults in his treatise that a clearer view of the theory in its broader sense is due.

§ 65. The second circuital law, like the first, had an experimental origin, of course, and, like the first, was long in approximating to its present form—much longer, in fact, though in a different manner. The experimental foundation was Faraday's recognition that the voltage induced in a conducting circuit was conditioned by the variation of the number of lines of force through it.

But, rather remarkably, mathematicians did not put this straight into symbols for an elementary circuit, but went to work in a more roundabout way, and expressed it through the medium of an integration extended along a concrete circuit; or else, of an equation of electromotive force containing a function called the vector potential of the current, and another potential, the electrostatic, working together not altogether in the most harmoniously intelligible manner—in plain English, muddling one another. It is, I believe, a fact which has been recognised that not even Maxwell himself quite understood how they operated in his "general equations of propagation." We need not wonder, then, that Maxwell's followers have not found it a very easy task to understand what his theory really meant, and how to work it out. I had occasion to remark, some years since, that it was very much Maxwell's own fault that his views obtained such slow acceptance; and, in now repeating the remark, do not abate one jot of my appreciation of his work, which increases daily. For he devoted the greater part of his treatise to the working out and presentation of results which could be equally well done in terms of other theories, and gave only a very cursory and incomplete exposition of what were peculiarly his own views and their consequences, which are of the utmost importance. At the same time, it is easily to be recognised that he was himself fully aware of their importance, by the tone of quiet confidence in which he wrote concerning them.

Finding these equations of propagation containing the two potentials unmanageable, and also not sufficiently comprehensive, I was obliged to dispense with them; and, going back to first principles, introduced what I term the second circuital law as a fundamental equation, the natural companion to the first. The change is, I believe, a practical one, and enables us to considerably simplify and clarify the treatment of general questions, whilst bringing to light interesting relations which were formerly hidden from view by the intervention of the vector potential **A**, and its parasites J and Ψ.

Another rather curious point relates to the old German electro-dynamic investigations and their extensions to endeavour to include, supersede, or generalise Maxwell by anti-Maxwellian methods. It would be slaying the slain to attack them; but one point about them deserves notice. The main causes of the variety of formulæ, and the great complexity of the investigations, were—first, the indefiniteness produced by the want of circuitality in the current, and next the potential methods employed. [J. J. Thomson's "Report on Electrical Theories" contains an account of many. As a very full example, that most astoundingly complex investigation of Clausius, in the second volume of his "Mechanische Wärmetheorie," may be referred to.] But if the critical reader will look through these investigations, and eliminate the potentials, he will find, as a useful residuum, the second circuital law; and, bringing it into full view, will see that many of these investigations are purely artificial elaborations, devoid of physical significance; gropings after mares' nests, so to speak. Now, using this law in the investigations, it will be seen to involve, merely as a matter of the mathematical fitness of things, the use of another, viz., the first circuital law, and so to justify Maxwell in his doctrine of the circuitality of the current. The useful moral to be deduced is, I think, that in the choice of variables to express physical phenomena, one should keep as close as possible to those with which we are experimentally acquainted, and which are of dynamical significance, and be on one's guard against being led away from the straight and narrow path in the pursuit of the Will-o'-the-wisp.

As regards the terms in the expression of the second law which stand for unknown properties, they may be regarded merely as mathematical extensions which, by symmetrizing the equations, render the correct electric and magnetic analogies plainer, and sometimes assist working out. But some other extensions of meaning, yet to be considered, have a more substantial foundation.

LIGHTNING CONDUCTORS.

BY DR. OLIVER LODGE.

(*Concluded from page 9.*)

Effect of inserting Long Leads in the A portion of the Circuit.

§ 63. So far, the various long wires round the room had been used as alternative path, *i.e.*, had been made to shunt the B spark. I now proposed to insert them into the circuit in another place, so that while they exerted their full effect on the frequency and damping of the oscillations, they should not otherwise directly affect the B spark, which was to be shunted by a distinct and constant conductor.

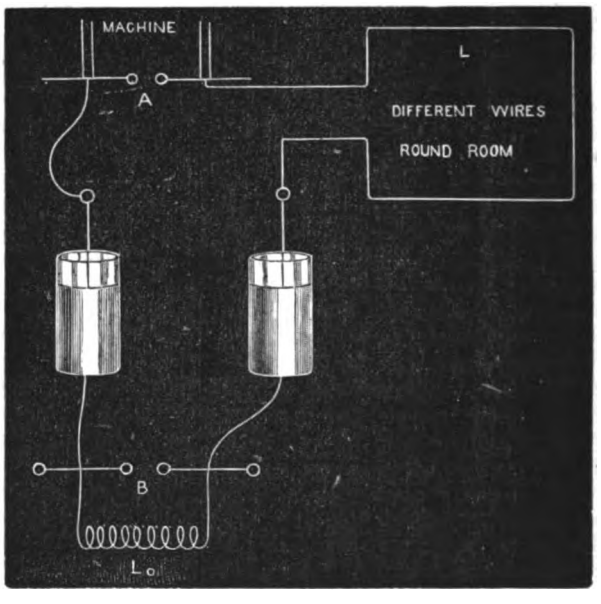

FIG. 11.

For this latter purpose I wound on a glass lamp chimney a spiral of copper wire of the following dimensions:

685 centims. of No 12 copper wire in 39 turns.

Diameter of each turn 5·5 centims. Thickness of wire ·24 centims. Total length of spiral 28 centims. Free ends, 13 centims. the two, attached to spark micrometer. A pair of No. 16 copper wires, 18 inches each, joined the micrometer to the outside coats of the gallon jars standing on insulating stool as shown in Fig. 11.

The spiral was easily detachable, and so the alternate path was either this spiral or nothing.

One or other of the long leads round the room was now used to join the knob of one of the jars to the machine. The knobs of the machine were set 4 centims. apart, and the experiment was ready to begin. Connection shown in Fig. 11.

It was found that under these circumstances (as had often been found before), *i.e.*, with a long lead in the main circuit, the jar to which it was connected was very apt to overflow, *i.e.*, to spark round its edge, a distance of 8 inches; this tendency being more marked when the circuit is formed of

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good conductors than when the resistance and consequent damping of oscillation is considerable.

The leads inserted in the main circuit were the same as have already been described—viz., about 27 metres of No. 12 and of No 27 of iron, copper, and lead respectively.

October 15th, 1888. The following was the result :—A spark length 4·0 centims.

Lead in Main Circuit.	Alternative Path.	Length of max. B spark.	Remarks.
Thin copper...	None	9·178	Jar does not overflow.
,,	Copper spiral	·763	Jar sometimes overflows.
Thick copper.	None	9·460	Does not overflow.
,,	Copper spiral	approximately ·9	But jar now overflows every time.
Thin iron.....	None	8·0	Decidedly shorter than with copper.
,,	Copper spiral	·745	Jar sometimes overflows.
Thick iron ...	None	9·135	
,,	Copper spiral	·80	Overflows rather often.
Thin lead.....	None	7·525	
,,	Copper spiral	·778	Sometimes overflows.
Thick lead ...	None	8·79	
,,	Copper spiral	·850	Overflows nearly every time.

Thus, unless the circuit is closed by the alternative path, there is no overflow of the jar, but the maximum B spark is very long, about twice as long as the exciting A spark. When the air-gap is bridged by the copper spiral, overflow occurs, but much more easily with the thick copper lead than with the others.

The reason why the B spark is so short is because the main part of the circuit is so long, *i.e.*, because in the approximate formula

$$\frac{B}{A} = \frac{L_0}{L + L_0},$$

because L is much greater than L_0. (L_0 is the inductance of the alternative path ; L is the inductance of the rest of the circuit.)

Long Leads in both A and B portions of Circuit.

§ 64. The same arrangement of jars, &c., was tried again on October 17th, but some one or other of the long leads was used as the alternative path, while another of them, viz., the thin copper, was included in the main or A portion of the circuit. Fig. 11 is to be modified by removing the spiral marked L_0 and substituting another long wire, like L. The remarks appended in the last column of the following table, showing the number of times the B spark occurs and the number of times it fails under given circumstances, are useful as indicating the sharpness of the adjustment and the range of uncertainty.

Alternative path.	Length of B spark-gap in centimetres.	Remarks.
None	7·90	...
Thin iron	1·36	2 B sparks occur in 10 attempts.
,,	1·35	3 sparks in 6 attempts.
Thick copper ...	...	Spits over edge of jar every time.
Thin lead	1·240	2 B sparks pass in 17 attempts.
,,	1·225	2 ,, ,, 8 ,,
,,	1·213	6 ,, ,, 6 ,,
Thick iron	1·162	6 ,, ,, 8 ,,
,,	1·175	2 ,, ,, 7 ,,
,,	1·201	1 ,, ,, 13 ,,
Thick lead	1·075	3 ,, ,, 3 ,,
,,	1·087	3 ,, ,, 6 ,,
,,	1·100	1 ,, ,, 10 ,,

With the thick iron the jar spits rounds its edge pretty often, and with the thick lead it does so nearly every time. With the thick copper, as stated above, it always does so, and hence no satisfactory readings could be taken with it.

Experiments on the Effect of Mutual Induction between A and B portions of Circuit.

§ 65. But since the two leads used in this experiment both went round the same room, and not more than a foot apart, there is some mutual induction between them ; so observations were made, noticing carefully whether the discharge was going the same way round the two wires or the opposite way round. The main circuit conductor was still the thin copper wire, and the alternative path was one of the others. When the current goes the same way in both I call it the concurrent arrangement; when opposite ways, non-concurrent.

The A spark was shortened to 3·5 centims. in order to avoid so much overflowing of the jars.

Alternative path.	Length of B spark.
Thin iron, concurrent arrangement	1·34
Ditto non-concurrent	1·30
Ditto concurrent again	1·33
Thick copper, concurrent	·95
Ditto non-concurrent.....	·84
Ditto concurrent again	·95

Thus the effect of mutual induction was slightly to increase the apparent impedance of the alternative path when its current flowed in the same direction as that in the main circuit. But the effect is not great. The fact is that L and L_0 are both affected together, and so the effect on the ratio $\frac{L_0}{L + L_0}$ is unimportant.

Effect of Diminishing Self-induction in B Circuit.

§ 66. A zigzag of wire was now prepared, consisting of the same length of the same wire as those round the room, wound zigzag on pegs on a board. A pair of wires were thus prepared, one of thin iron the other of thin copper. The thin copper wire round the rooms was still kept in the A circuit, and, in fact, everything else remained as it had been.

There was now, of course, no mutual induction between the parts of the circuit.

Alternative Path.	Length of B spark.
Thin iron zigzag	·97 centims.
Thin copper zigzag	·71 ,,

Substitute now in the A circuit the thin copper zigzag instead of the thin copper wire round room ; leave all else the same. (A spark still 3·5 centims.)

Alternative Path.	Length of B spark.
None	4·95 centims.
Thin iron zigzag.....	4·13 ,,

The diminution of L has brought up the length of the B spark tremendously.

Effect of the Light of One Spark in Assisting the Other.

§ 67. A large number of similar experiments were made, combining the zigzags with the wires round the room in various ways, and inserting other things in the A portion of the circuit ; but it is unnecessary to reproduce any more of these. As has been previously noticed (see §§ 43 and 45, Vol. XXII., p. 246), the adjustment of the maximum B spark was often found to be different when it could see the A spark from what it was when the light of the A spark was screened from it. The effect is not very large, and the conditions have to be such as give fair sensitiveness to the B spark—*i.e.*, those which make it neither very short nor very long ; but, under these conditions, the effect of the light of the A spark in assisting the passage of a discharge across the B spark-gap is quite distinct, even when the two sparks are not at all close to each other. The following extract indicates this :—

October 24th.—Spiral on lamp glass (§ 63) in A circuit, as shown in Fig. 11 of L and L_0 are interchanged. A spark length 3·5 as before.

The effect of the light of one spark in helping the other is plain enough in the above "thin copper wire round room ;" but it was repeated and verified with many other arrange-

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ments. It had been previously observed in another manner by Hertz.

Alternative Path.	Condition as to Light.	Length of B spark.	Remarks concerning B spark.
None	Light of A screened off	7·0	...
„	Light of A visible at B	7·0	...
Thin Copper Wire round room	Light visible	2·775	9 sparks pass out of 10
„ „ „	„	2·800	5 „ „ 10
„ „ „	„	2·825	1 „ „ 10
„ „ „	Light screened off	2·675	6 „ „ 10
„ „ „	„ „	2·700	2 „ „ 10
„ „ „	„ „	2·725	1 „ „ 10
„ „ „	„ „	2·750	0 „ „ 10
Thin Iron round room	Light visible	2·48	...
Thin Lead round room	„	2·63	...
Thick Lead	„	2·65	...
Thick Copper	„	2·52	...
Thick Iron	„	2·40	...
Thin Iron zigzag	„	1·88	...
Thin Copper zigzag	„	1·58	...
Old No. 5 Copper circle, § 42	„	·20	...
Old No. 2 Iron circle	„	·19	...
No. 26 Iron circle	„	·29	...
No. 26 Copper circle	„	·24	...
No. 18 Iron circle	„	·24	...
No. 18 Copper circle	„	·23	...

Experiment to compare Zigzags with Spirals of the same length.

§ 68. The same kind of wire as had been used for the zigzags (27 meters) was now wound on an open wooden frame in a spiral, say, a yard long and a foot square or thereabouts, with about an inch between the different turns.

The small spiral on lamp glass of § 63 was put in A circuit, and A spark adjusted to 3·5 centims. [Setting of A spark not precisely accurate from one day to another.] The following is a typical selection from the readings :—

Alternative Path.	Length of B spark.	——
None	7·93	
Thin copper zigzag	1·70	
Thin iron zigzag	1·88	
Thin iron spiral	3·36	
Thin copper spiral	4·03	but overflows jar nearly every time.
Both zigzags in series	2·2	

Thus, the effect of increasing L_0 on the length of B spark, everything else remaining the same, is very marked. The figures show that either spiral offers far more impedance than both the zigzags (of the same wire exactly) in series.

This is the end of the account of my experiments on "The Alternative Path."

MEMORANDUM ON THE PREPARATION OF THE CLARK'S STANDARD CELL.

The following draft memorandum has been drawn up for the consideration of the Electrical Standards Committee of the Board of Trade :—

Definition of the Cell.

The cell consists of zinc and mercury in a saturated solution of zinc sulphate and mercurous sulphate in water, prepared with mercurous sulphate in excess, and is conveniently contained in a cylindrical glass vessel.

Preparation of the Materials.

1. *The Mercury.*—To secure purity it should be first treated with acid in the usual manner, and subsequently distilled in vacuo.

2. *The Zinc.*—Take a portion of a rod of pure zinc, solder to one end a piece of copper wire, clean the whole with glass paper, carefully removing any loose pieces of the zinc. Just before making up the cell dip the zinc into dilute sulphuric acid, wash with distilled water, and dry with a clean cloth or filter paper.

3. *The Zinc Sulphate Solution.*—Prepare a saturated solution of pure ("pure re-crystallised") zinc sulphate by mixing in a flask distilled water with about twice its weight of crystals of pure zinc sulphate, and adding a little zinc carbonate to neutralise any free acid. The whole of the crystals should be dissolved with the aid of gentle heat, and the solution filtered, while still warm, into a stock bottle. Crystals will form as it cools, and when the solution is to be used a little should be taken from the bottom of the bottle near the crystals with a pipette. While this is being done the liquid should be at a decidedly higher temperature than that at which the cells will ordinarily be used.

4. *The Mercurous Sulphate.*—Take mercurous sulphate, purchased as pure, and wash it with distilled water. Drain off as much of the water as possible. Mix the washed mercurous sulphate in a mortar with the zinc sulphate solution, adding sufficient crystals of zinc sulphate from the stock bottle, to ensure saturation, and a small quantity of pure mercury. Mix these well together to form a paste of the consistence of cream, and then heat the paste sufficiently to dissolve the crystals, afterwards allowing the mixture to cool, and thus to form a saturated solution of mercurous sulphate in a saturated solution of zinc sulphate.* The presence of the free mercury through out the paste preserves the basicity of the salt, and is of the utmost importance.

Contact is made with the mercury by means of a platinum wire about No. 22 gauge. This is protected from contact with the other materials of the cell by being sealed into a glass tube. The ends of the wire project from the ends of the tube ; to one end a piece of copper wire is soldered, the other end and a portion of the glass tube dip into the mercury.

To set up the Cell.

The cell may conveniently be set up in a small test tube of about 2cm. diameter, and 6 or 7cm. deep. Place the mercury in the bottom of this tube, filling it to a depth of, say, 1·5cm. Cut a cork about ·5cm. thick to fit the tube ; at one side of the cork bore a hole through which the zinc rod can pass tightly ; at the other side bore another hole for the glass tube which covers the platinum wire ; at the edge of the cork cut a nick through which the air can pass when the cork is pushed into the tube. Pass the zinc rod about 1cm. through the cork.

Clean the glass tube and platinum wire carefully, then heat the exposed end of the platinum red hot, and insert it in the mercury in the test tube, taking care that the whole of the exposed platinum is covered.

Shake up the paste and introduce it without contact with the upper part of the walls of the test tube, filling the tube above the mercury to a depth of rather more than 2cm.†

Then insert the cork and zinc rod, passing the glass tube through the hole prepared for it. Push the cork gently down until its lower surface is nearly in contact with the liquid. The air will thus be nearly all expelled, and the cell will be ready for sealing.

Melt some marine glue until it is fluid enough to pour by its own weight, and pour it into the test tube above the cork, using sufficient to cover completely the zinc and soldering. The glass tube should project above the top of the marine glue.

The cell thus set up may be mounted in any desirable manner. It is convenient to arrange the mounting so that the cell may be immersed in a water bath up to the level of, say, the upper surface of the cork. Its temperature can then be determined more accurately than is possible when the cell is in air.

* Note.—If the saturated solution of zinc sulphate is not heated, the cells do not usually agree with each other until some time after they have been set up. If the above method is followed, the agreement is good at the time of setting up, and should be very close indeed after a day's rest. Care, however, must be taken that the paste is not super-saturated when cold.

† When the cell has been set up for a little time the more solid portion of the paste sinks to the bottom leaving clear liquid above.

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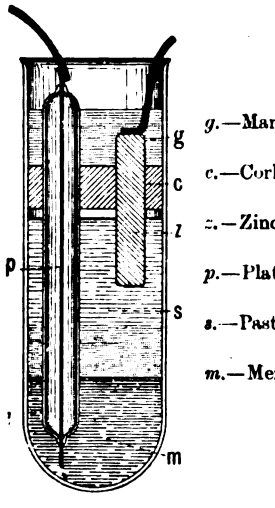
This figure, which does not form part of the memorandum, has been prepared in accordance with the particulars given therein.



PROF. EWING'S THEORY OF MAGNETISM.*

BY ARTHUR HOOPES.

The "Theory of Induced Magnetism" which Prof. Ewing published in the *Phil. Mag.* for September, 1890, is at once so beautifully simple and comprehensive that we have thought that some magnetisation curves actually obtained from the model which he suggests might be interesting as testing, in some degree, the efficiency of the hypothesis. With this end in view the accompanying curves were determined by the writer, under the direction of Dr. Henry Crew, of Haverford College.

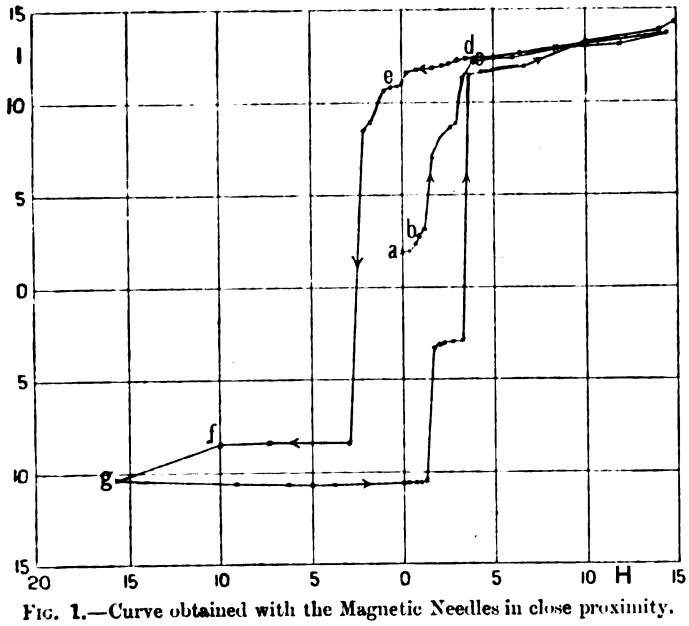


FIG. 1.—Curve obtained with the Magnetic Needles in close proximity.

The magnets used were similar to those described by Prof. Ewing, about 2in. long and balanced on sewing needles set in lead bases. They were 68 in number, and were placed in three layers or tiers on glass plates, which slipped into the magnetising coil. The coil was 32in. and 12in. in diameter, and was wound from end to end with 76 turns of wire. It was set with its axis east and west. The magnetic moment of the model was measured by a magnetometer 34in. from the middle of the coil. To eliminate the magnetic effect of the current in the coil, an opposing coil was adjusted on the other side of the magnetometer at such a distance that it just balanced the large coil when the magnets were out. The maximum strength of field used was about 2·7 C.G.S. units, or 15 times the horizontal component of the earth's field.

The method of obtaining the curves was simply to put in the magnets, stir them up and let them come to rest by themselves, then to vary the magnetising current through a cycle and read he magnetometer deflections at intervals. As no attempt was made to get anything but the *shape* of the curves, the tangents of the magnetometer and galvanometer deflections were plotted on a convenient scale, without regard to the absolute values of current and magnetic moment.

Figs. 1 and 2 show curves obtained with the magnets as close together as they could be placed without striking. They illustrate well the different results that may be caused by different initial directions of the magnets. The magnet *centres* were in almost the same positions in the two cases, but in Fig. 1 the magnets took the directions shown in Fig. 3, while for the curve of Fig. 2 the original state is shown by Fig. 4. Both curves show beautifully the small

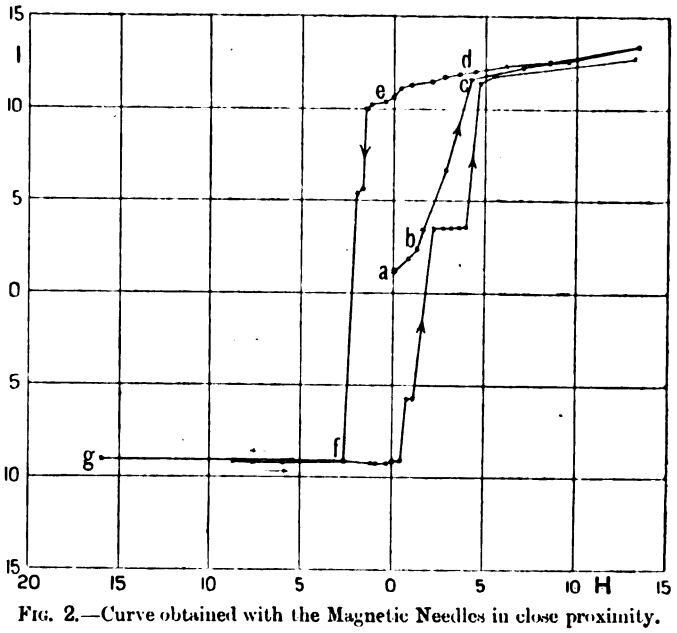


FIG. 2.—Curve obtained with the Magnetic Needles in close proximity.

susceptibility at first (*a* to *b*, Figs. 1 and 2), where the magnets are deflected through small angles, but have not yet passed through an unstable position. From *b* to *c* the magnets turned rapidly with small increase of current, and from *c* to the right they were brought more and more nearly into the direction of the axis of the coil, giving the flat part of the curve. On decreasing the current the curves almost retrace themselves to the point *d* directly above *c*, where stability begins. But here it leaves the ascending branch, because it takes less strength of field to *hold* them in this position than it required to

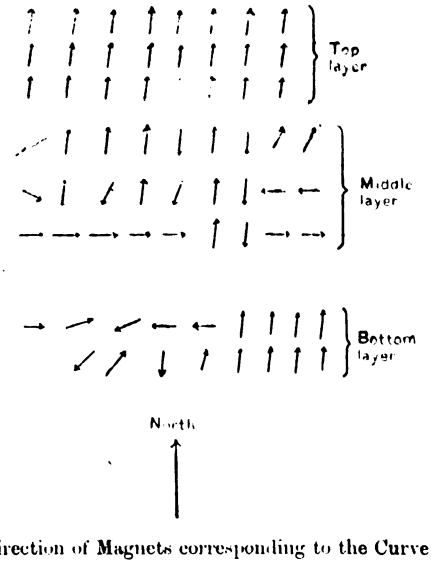


FIG. 3.—Direction of Magnets corresponding to the Curve in Fig. 1.

put them there. This state continues until the field is nearly zero strength, when two or three magnets turn, giving the small drop at *e*. A slight negative increase turns many more, and another reverses every remaining magnet except four, which are almost exactly opposite to the direction of the field. In Fig. 1 the increase from *f* to *g* turned these four, but in Fig. 2 they were not affected by the strongest current that could be used. Consequently the curve of Fig. 2 is almost horizontal between *f* and *g*. The differ

* From the *Electrical World* of New York.

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ence was probably due to a slight change in the position of the plate which supported these magnets. Completing the cycle, the upward branch of Fig. 1 is seen to consist of two main steps, while Fig. 2 has three, and both curves are to the right of the origin.

These curves may possibly represent one group of molecules in a steel bar. Since the mean density of steel is nearly the same as that of iron, it appears that the large hysteresis of the former is due to the molecules in individual groups being nearer, the groups themselves being further apart than in soft iron. To diminish the hysteresis of the model, the magnets must be placed further apart, in order to lessen the stability of their positions. The area of the curve can thus be decreased indefinitely. The curve of Fig. 5 was taken with the magnet centres 2½in. apart—that is, with

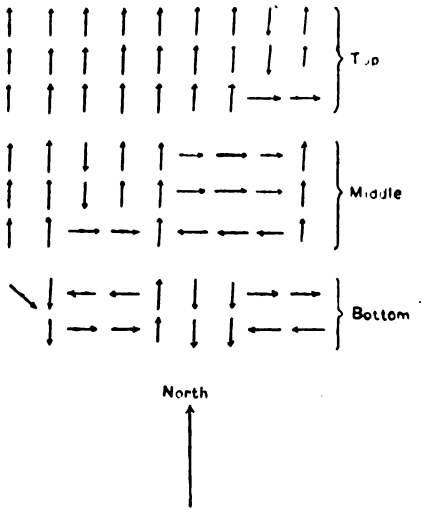


Fig. 4.—Direction of Magnets corresponding to the Curve in Fig. 2.

the magnet ends ½in. apart at the closest. In this curve the cycle was performed in the opposite direction to that of the others. The last downward branch is dotted to distinguish it from the first. The area of the curve suggests at once that if Figs. 1 and 2 represent the case of steel, Fig. 5 represents soft iron—that is, the case in which there is a less intimate connection of the molecules in their respective groups.

At *b* a small cycle* was superposed upon the main cycle, as shown by the small loop. At *c* the loop returns to the main curve. If one of these minor cycles be performed at a point like *d*, which represents a stable position of the magnets, the curve merely retraces itself, illustrating the fact that there is no hysteresis without

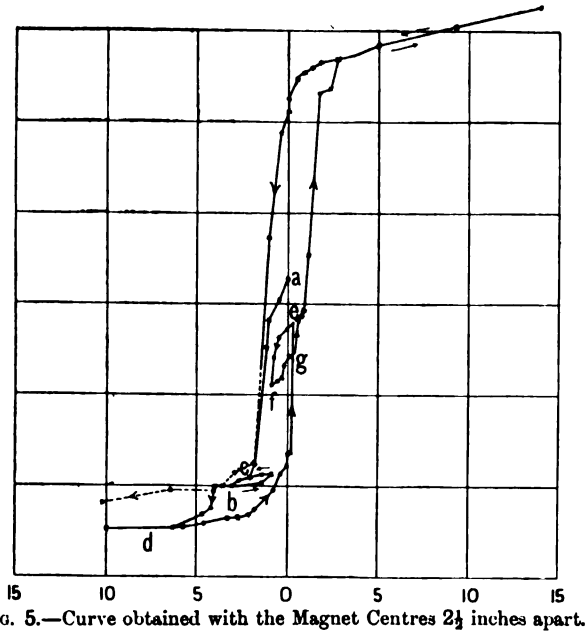


Fig. 5.—Curve obtained with the Magnet Centres 2½ inches apart.

passing through a position of instability. On the contrary, at a point like *e*, where nearly half of the magnets have just turned, the area is very large. It is interesting to note that the curve took a new track at *g* instead of returning to *e*.

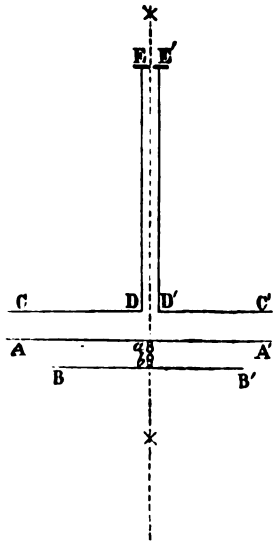
* Lord Rayleigh, *Phil. Mag.* March 1887

These are a few of the curves which have already been obtained from the model. They are necessarily very imperfect, largely on account of the relatively small number of magnets used. They suffice to show, however, the close resemblance of the model to actual magnetic metal, as far as the most important properties are concerned, which was all that was originally expected

ON THE DETERMINATION OF THE DIELECTRIC CONSTANT OF GLASS BY THE AID OF VERY RAPID ELECTRICAL OSCILLATIONS.*

BY R. BLONDLOT.

Very rapid electrical oscillations, such as those produced by Hertz's apparatus, have been used by J. J. Thomson for the determination of dielectric constants.† J. J. Thomson draws the following conclusion from his experiments:—"With oscillations of the order of 25,000,000 per second, the specific inductive capacity of glass is nearly equal to the square of its index of refraction, and is considerably less than it is for slower reversals." It may be objected to this conclusion that a formula is employed involving the period of the oscillations, and that the accuracy of the formula is doubtful in the case of very rapid oscillations. E. Lecher has determined the dielectric constants of several substances by means of a method also based on the determination of the wave length of very rapid



oscillations, but without using any formula. The conclusions of Lecher are diametrically opposed to those of J. J. Thomson. He remarks, "not only does the dielectric constant determined by aid of the capacity not become smaller for very rapid oscillations, but it even notably increases." These contradictory conclusions induced me to investigate the matter. The method which I used is based upon the employment of very rapid oscillations, but does not involve any formula.

A large rectangular brass plate, A A′, is fixed vertically, and a second smaller plate, B B′, forms a condenser with the first. This condenser can discharge itself by means of the poles *a b*; *a* being in communication with the gas tubes and *b* with one of the poles of an induction coil, the other pole of which communicates with the gas tubes. When the induction coil is at work the condenser A B is the seat of oscillatory charges and discharges, the period of which is of the order of $\frac{1}{100000000}$ of a second. We thus have in the space situated on the side of A A′ opposite to B B′ a periodic electromagnetic field which (and this is the important point) has X X as its plane of symmetry. Two square plates, C D and C′ D′, were fixed parallel to A A′, and symmetrically with regard to X X, and at the points D D′, two wires were soldered, terminating at E and E′ in two electric light carbon pencils arranged opposite to one another in close proximity.

When the coil is set in operation no glow is to be seen between E and E′. This is due to the symmetry of the apparatus. If we now interpose between A A and C D a sheet of glass, sparking immediately takes place between E and E′. This is due to the fact that the induction received by C D is stronger than that received by C′ D′. If we now place a sheet of sulphur between A A and C′ D′,

* *Comptes Rendus*, Vol. CXII, No. 19. † *See* Proc. Roy. Soc., June, 1889.

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and if we give it a thickness such that the inductive action on C′ D′ is equal to the inductive action on C D, the sparking between E and E′ ceases. Reciprocally the disappearance of sparking at E E′ ndicates that the inductions transmitted to C D and C′ D′ are equal. It suffices, therefore, to measure the thickness of the dielectric to determine by an easy calculation the ratio of the dielectric constants of glass and sulphur. Thanks to experimental precautions, which I cannot describe here, I was able to render this method sensitive and precise.

The plate of glass which I employed was exactly 3cm. thick. I melted two sheets of sulphur in the form of prisms of the same angle, so that in placing them side by side, as in the Babinet compensator, a sheet with parallel faces is formed, the thickness of which can be varied. I found 3·15cm. to be the thickness of the sheet of sulphur, exactly compensating the sheet of glass. To complete the determination of the dielectric constant of glass, it was necessary to know that of sulphur. This was easy, since sulphur is an almost perfect dielectric. I employed the method described by J. Curie,* and I found the number to be 2·94, and from this deduced the dielectric constant of glass to be $2·8 (=1·67)^2$.

This result one can see is nearly identical with that of J. J. Thomson. Maxwell's law is not verified exactly, since the mean index of refraction of my glass sheet was about 1 51, but the discrepancy is a great deal less than that observable in the value of the dielectric constant obtained by slower methods. My conclusion is the same as that of J. J. Thomson.

TELEGRAPHIC AND TELEPHONIC CABLES IN THE ST. GOTHARD TUNNEL.†

As soon as the St. Gothard Tunnel was complete, the telegraphic administration laid, during the winter of 1881-82, a seven-core cable for the telegraphic service of the State and the Railway Company. In addition, a single wire cable was laid for use in connection with the signal boxes installed at the 14 kilometric stations in the tunnel. The cables were made by Felten and Guillaume, of Mulheim, and each of the cores consisted of seven wires, ·7mm. in diameter, and insulated by four coatings of gutta-percha and Chatterton compound, having then a diameter of 5 2mm. The whole was then wound with tarred hemp, armed with a covering of galvanised iron wire, and finally covered with a coating of jute having a thickness of 3mm. After a survey of the tunnel, the cable was placed in an iron trough, fixed to the wall of the tunnel at a height of 2·4 metres above the permanent way, the trough being enclosed in a creosoted wood casing. In spite of the excellent quality of the cables, and the care with which they were laid, serious defects soon came to light, the insulation of 3,000 megohms per kilometre descending at times to five megohms and frequent disturbances of the service resulted. A careful investigation of the situation showed what were the causes of this abnormal state of the cables, causes which, although present in all tunnels of any size, seem sufficiently interesting to warrant careful analysis.

The water which filters into the tunnel is very abundant, amounting to nearly 300 litres per second (66 gallons per second, or 5,700,000 gallons per day). It may be interesting to observe, in passing, that at the entrance of the tunnel this water feeds a fall of 15 metres, which works a turbine driving the two dynamos supplying light to the station and village of Airolo.

The firm of Siemens and Halske, the contractors for the new cable, analysed 150 bottles of infiltration water taken from various places in the tunnel. Several of the samples contained considerable quantities of sulphuretted hydrogen. Moreover, an examination of the stagnant water in the trough showed that it contained all the ingredients favourable to a rapid corrosion of the protective covering of the cable; ingredients produced by the incomplete combustion of the coal of the locomotives in an atmosphere almost denuded of oxygen. The products of combustion, it may be added, have had a very marked effect on the permanent way. These analyses showed the danger of placing cables in a trough arranged along the sides of the wall, and pointed to the conclusion that the best way would be to place the cables under ground in a bed of sand, so as protect them from the destructive action of the water and the atmosphere of the tunnel. It was evident that care must be taken in tapping and diverting the springs, which rise from the soil at several points in the tunnel, all the more so because these springs were slightly sulphurous. Prudence also demanded that the cable should be covered with a completely impermeable coat of lead, the whole being protected with solid stone slabs.

The railway company, therefore, ordered two cables from Messrs. Siemens and Halse, the data of which were determined by traffic exigences, as well as by the considerations referred to above. One cable was intended for telegraphic purposes, and had three cores; the second cable was a concentric telephone line. The following are the data of these two cables:—

Each wire of the telegraph cable was of pure copper, and was 1·38mm. in diameter, covered with three layers of jute to a total diameter of 4·4mm., and enclosed in a lead covering 1·3mm. thick. The three wires were then bound together, and the whole enclosed in a covering of paper and asphalt, which, in its turn, was protected by a sheath formed of 20 galvanised iron wires 3·75mm. in diameter, the external diameter of the cable being 33mm.

The following are the electrical constants per kilometre, at 16°C.:—

Resistance	11·5 to 12 ohms.
Insulation	500 megohms.
Capacity	·25 microfarad.

The telephone cable had an interior core, consisting of a single wire 1mm. in diameter, wound with jute to a diameter of 2·5mm. This was then surrounded by a layer of seven wires each ·4mm. in diameter, and metallically united to each other by tin-foil. The whole was then wound with strands of jute (4·4mm. in diameter), and enclosed in a lead covering 1·3mm. thick, the external diameter of the whole being 7mm. This was, in turn, protected by a layer of paper and asphalt, a sheath of 16 galvanised iron wires coming next, a final protective coating, having an asphalt base, being then put on. The constants are as follows at 15°C.:—

External diameter	24 mm.
Resistance per kilometre	·25 ohms.
Insulation	250 megohms.
Capacity	·31 microfarad.

This telephone cable was joined up to the fourteen telephonic posts in the tunnel, and to the stations at either end.

In laying the cable, a trench 50 to 80cm. deep was excavated; at the bottom there was a layer of gravel 10cm. thick, then came a layer of sand 10cm. thick, then the cables, then a layer of sand 20cm. thick, then a granite slab, and finally gravel. The work of laying occupied two whole months, namely, from September 15th to the middle of November of last year, work being only possible at night time, during the train intervals. To the many difficulties encountered must be added the pestiferous atmosphere of the tunnel, and the violent wind from north to south, which always blows in the tunnel. The work required 500 loads of sand, 250 of slabs, 32 of cables, and 500 of excavated earth.

* *Annales de Chimie et Physique*, 1889.

† From an abstract in *La Lumière Electrique* of a detailed report by Herr Baechtold, which appeared in the *Elektrotechnische Zeitschrift*.

BOOKS, &c., RECEIVED.

"Officieller Katalog der Internationalen Elektrotechnischen Ausstellung in Frankfurt-am-Main." (Frankfurt.)

"Transactions of the Canadian Institute." Vol. I., Part 2. (Toronto: The Copp, Clark Company.)

"Der Betrieb und die Schaltungen der Elektrischen Telegraphen." Vol. III. By Dr. Karl Eduard Letzsche. (Halle-a-S.: Wilhelm Knapp.)

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9 p.m. Evening Discourse: "An Astronomer's Work in a Modern Observatory." By DAVID GILL, F.R.S.

SATURDAY, May 30th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Scientific Study of Decorative Colour." By Prof. A. H. CHURCH, F.R.S.

MONDAY, June 1st.

ROYAL INSTITUTION.

5 p.m. General Monthly Meeting.

FRIDAY, June 5th.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "The Implications of Science." By ST. GEORGE J. MIVART, M.D., F.R.S.

SATURDAY, June 6th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Scientific Study of Decorative Colour." By Prof. A. H. CHURCH, F.R.S.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

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POPULAR SCIENCE.

The widespread interest in popular science which is exemplified in the numerous books, journals, and lectures of the day, dates back only about half a century, and was probably due in a large degree to the charm of Faraday's discourses. The exact period at which it first arose is impossible to define, if only because the diversion of to-day was the erudition of our ancestors. From the accounts, and indeed the official records, of the transactions of the Royal Society in its early beginnings, it appears that its members often busied themselves about matters that would now seem very trifling to any well-informed person. But while such dilettanti as SAMUEL PEPYS were in a prominent position among the followers of science, it was then, as now, difficult to draw the line between men who are merely interested in the results of science and those who follow it as a pursuit, whether professionally or no. The books which deal with popular science might be considered as introductory to its proper understanding, and indeed many of us owe much to Prof. PEPPER and others; but the crowded theatre of the Royal Institution on Friday evenings, to say nothing of the other meetings both there and elsewhere, show that the intelligent and well-educated public take a keen interest in a good scientific lecture as an end in itself, and not as the commencement of a scientific education.

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The questions sometimes arise, What good does it do them, how much do they understand? and how much will they carry away with them? These questions should be commended rather to the consideration of the teachers than to their hearers. A well-known name or a neat title will draw the audience. The man need never have lectured before if only he is well enough known; he will draw, at least, once.

If the lecturer treats his subject skilfully, the listener finds it easier and more congenial to take in a little diluted science in this way, than by spending the same amount of time over a book. Even if the ideas gathered by the audience are few and indefinite, the essence of the matter may still have been imparted, for it may be safely asserted that a person who attends a number of independent lectures gradually acquires the power of following them. The desirable thing to spread among the people is not so much the knowledge of facts, as the education of the scientific faculties. This can only be done on a large scale by arresting the attention by lecturing, since few people take sufficient interest to acquire science for themselves. Books are dead things, but the popular lecturer can impart a vivid interest to his subject which can be obtained in no other way.

Popular science naturally divides itself into two kinds, the one can be readily appreciated by the public, and the other is dished up in such a shape that it appears pretty and amusing. The first is to be found in our lecture-rooms, and the second in French illustrated books—we cannot say literature. So long as science is not distorted in the endeavour to make it interesting, or forced into playing tricks unworthy of a good conjuror, facts which have a practical bearing on modern life, or which have a beauty of their own, are worth illustrating. In almost any man's work there are fragments which can be assimilated by anybody of intelligence, though the bulk of it may be very hard to digest. The theory of electric images is to be found in mathematical treatises and rarely elsewhere, but Sir William Thomson treated it experimentally in such a manner on a recent occasion, that no one who then became acquainted with the subject for the first time could have thought that it was even a subject for a mathematician to deal with. While there are many difficulties in the way of the teacher, whose endeavour must always be to suppress complications, and who is compelled to conventionalise at the expense sometimes of accuracy, the listeners are often rather bothered with the discovery of their own ignorance, are impatient of details, and are often on the verge of being bored. No doubt the true method of learning a science is to begin at the elements, and having mastered the principles, to study the phenomena in the light of these principles, just as languages are taught on a foundation of grammar. But it is generally conceded that grammar is a matter of discipline, a form of mental exercise useful for young minds, rather than an efficient means of learning a language; nor can the grammar of a tongue be fully appreciated until considerable progress has been made. No schoolmaster with a proper respect for the traditions of his trade will admit this, of course; and with the same instinctive feeling some men think that the pearls of knowledge which have been purchased at the price of hard study must not be cast before the swine of a fashionable audience. But this is mere selfishness.

If electrical science is to be studied by first mastering the principles, what are these principles, and who has mastered them? Are not the foremost thinkers of the day engaged in attempting to penetrate the threshold of these principles, and are not the elementary facts among the hardest to thoroughly understand? A good deal of the so-called popular science of to-day consists in the display of brilliant experiments, and the interest which the intelligent public take in witnessing experiments which they cannot possibly understand is somewhat remarkable. Sometimes their admiration is evoked by the admirable dexterity and manipulation of the lecturer, and often has Prof. Tyndall held his audience in breathless suspense, or has entranced them with the real beauty of his skill, and it is largely to him that we owe this system of education by the eye. The chain of silver links and platinum cannot but convey the lesson that substances differ in their specific resistance, even if the careless hearer forgets which metal glowed and which remained cool. Occasionally the object lesson becomes all object and no lesson, and, as in demonstrations of polarised light, the lecturer is justified after a time in giving up any attempt to explain the technique of the pictures painted indeed by Nature, but in colours which appear only at the command of Science.

The object of pure science is to trace out truth, while applied science appeals to the pocket; but popular science endeavours to place truth in a pleasing form. It is an art which, like music, appeals to our senses, and it is often remarkable how much more we are interested in some application of a simple fact, than in the study of a natural law of much greater consequence. The faults of the eye, and the character of vision, are not very attractive subjects in themselves, but when skillfully made use of, as in the stereoscope, to produce a pleasing illusion, we are at once interested. A simple and clever improvement of this instrument is due to Mr. Schobben, and depends upon the well-known fact that pieces of red and green glass can be found, each of which is opaque to the light which passes through the other. When two stereoscopic pictures are projected on a screen by means of a double lantern shining through red and green glass, and the coloured images so formed are viewed through a pair of spectacles, the glasses of which are also red and green, each eye can perceive but one of the images through the glass in front of it, and all the appearance of solidity is obtained. The effect of converting the two dimensioned pictures into a solid landscape is so startling that one is at first inclined to think that the problem of the fourth dimension is reduced to finding an appropriate pair of spectacles. When this brilliant example of popular science was exhibited by Mr. Woodward at the Physical Society, on Friday last, the intense interest evinced in it by the grave and reverend seigneurs of the Society only showed how universally the popular element influences our appreciation of science.

ELECTRIC AND MAGNETIC THEORIES.

BY SILVANUS P. THOMPSON, D.SC.

(*Continued from page 65.*)

§ 11. We have next to consider the question of steady current flow. In this case there is not, so far as I am aware, any direct experimental proof that the energy furnished by the source is transferred by the external medium to that part of the circuit, when it is to be utilised or transformed into heat, light, or work. On the other hand, there is nothing in the way of experiment to support the notion that the energy is transmitted by an end thrust along the wire of the circuit. In the absence, therefore, of any direct proof either way, it is only logical to assume that the mode in which the energy is transferred is the same as in those cases previously considered, in which it was proved, by direct experiment, that energy was transferred across the medium. In the case of steady currents, so long as they are really steady, we have no evidence whatever of propagation of the action from point to point, either inside or outside the conductive circuit; nothing to give us

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the slightest information as to either the rate or the direction of the propagation of the action. The chemical evidence as to the propagation of current is quite compatible with the theory that the current flows from positive to negative, or with the theory that it flows in the reverse direction, or with the theory that there are two currents simultaneously flowing in opposite directions; and any theory which merely takes into account the flow of current and neglects the distribution of electric potential is obviously incompetent to deal with the question how the energy is propagated.

In the absence of direct proofs either way, I shall therefore content myself with a few descriptive paragraphs as to the propagation of energy, on the hypothesis that in the case of steady flow the energy is transferred across the dielectric medium, as it is in the case of variable currents.

§ 12. Consider, then, a circuit made up of a row of battery-cells AA′ acting as the source, and of some wires which are in part thick, but contain a thin piece B B′, which will become hot (Fig. 6). Accepting the hypothesis that the energy travels across the medium, the energy paths will be comparatively short; shorter than if it were supposed that the energy had to travel around the thick conducting wires at the ends. In reality, such energy paths will form a series of curvilinear tracks, after the fashion of the end view shown in Fig. 7, where A is a section of one of the battery-cells, and B that of the corresponding part of the thin wire. The energy starts off from the surface of the zinc plates, flowing outwards into space, and, swirling round, concentrates itself in exactly the amount necessary to keep up the heating effect at the point in question.

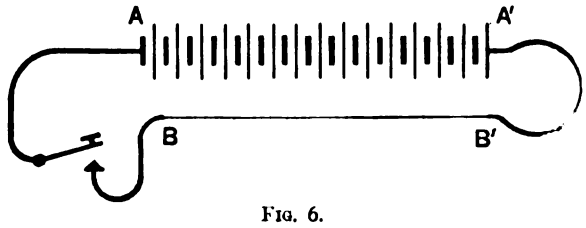

Fig. 6.

Again, consider Fig. 8. Here, a battery of seven cells, having small internal resistance, is connected to a thin wire which bends round from the positive pole P to the negative pole N. Let us assume, for the sake of simplification, that these cells have an electromotive force of one volt each. Let us apply a proper voltmeter, a quadrant electrometer, let us say,

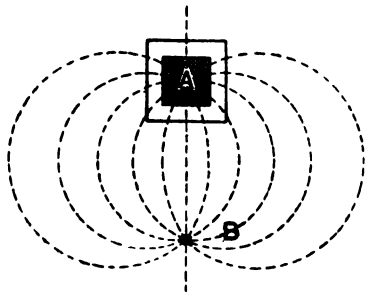

Fig. 7.

to measure the variations of potential. If one pole of the electrometer be connected to the negative terminal N, and connection be made successively from the other pole to various points along the row of cells, we shall observe 1 volt at the end of the first cell, 2 volts at the end of the second, and so on up to 7 volts at P. If we then go exploring in the same way along the wire we shall find that, beginning at N, there will be a certain point a little way along the circuit, marked 1, where the potential is 1 volt, further on 2 volts, and so on, ending with 7 volts at P. There will then be in this system two points at which the potential has the same values, one point in the row of cells, another point in the wire. But besides these two points in the conductive system there will be others in the surrounding space. For example, in the space surrounding the wire near the point marked 3, the potential will have a value of nearly 3 volts, and the dotted line drawn from 3 on the wire to 3 in the row of cells is intended to indicate the general position of such points of equal potential. In the same way, the dotted line 4, 4, marks the equipotential line, or rather surface, of four volts. It must be remembered that the equipotential surfaces will emerge from the battery normally all round, and will intersect the external circuit, also normally. The swirling lines of Fig. 7 would all lie in one equipotential surface. In the above statement it has been assumed that there is no chemical difference of potential between the metal and the medium to complicate matters by a difference of potential at the surface. One only needs to suppose the ordinary air to be replaced by nitrogen or other chemically inert material to realise the case. By purely mathematical reasoning, quite apart from the argument which I have put forward as to logical inference from the known cases to the unknown ones, Poynting and Heaviside inferred that the transfer of energy must take place in paths parallel to the surfaces of electric equipotential. The meaning of that proposition in relation to Fig. 8 is that the energy given out by each cell finds its way across the medium to the corresponding part of the external circuit. For example, the energy due to the combustion of zinc in cell No. 2, between points 1 and 2 in the row of cells, will go across the medium to supply the waste of energy that is being dissipated as heat between the points 1 and 2 of the wire; and the energy paths emerging out of this cell will consequently be limited by the dotted lines 1, 1, and 2, 2.

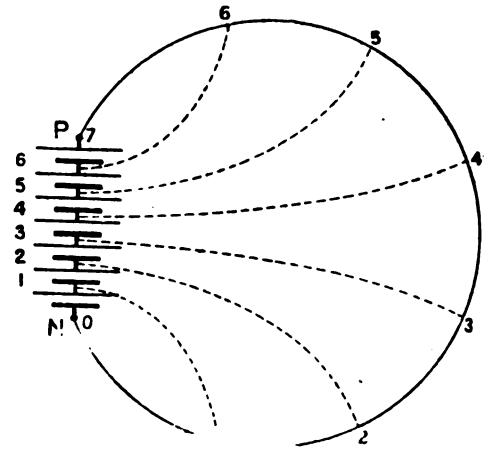

Fig. 8.

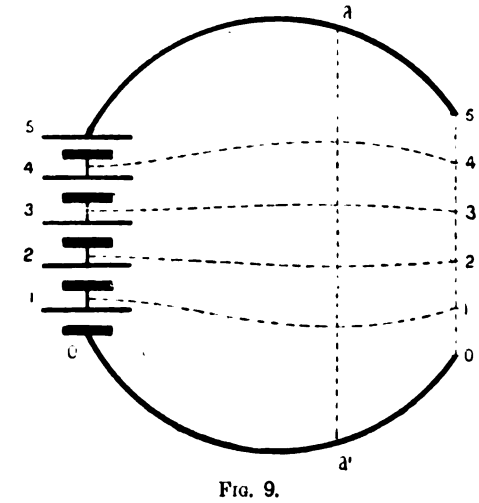

Fig. 9.

Fig. 9 is another variation of the same theme. Here are five cells, and the circuit is composed of two thick wires, with a thin piece interposed. If the cells are of small internal resistance, and of 1 volt apiece, the potential will rise from 0 to 5 volts, whether measured along the row of cells or along the wire. If one considers any line such as $a\,a'$ drawn across the circuit from one thick wire to the other, it is clear that between a and a' there is a difference of potential of 5 volts, and, as at

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intermediate points the potential must have intermediate values, points corresponding to 1, 2, 3, and 4 volts can be found. These lie, of course, in the equipotential surfaces, which can be drawn across the system. Surely it is more rational to suppose that the energy which heats the piece of wire between 0 and 1 comes from the corrresponding cell, and that which heats the next piece of wire from 1 to 2 comes from the next cell, than to suppose that the energy which heats any particular piece of the wire comes from nowhere in particular. According to the hydraulic notions, the energy which is to heat the piece of wire, 0, 1, has to be forced along the wire through all the other pieces, and, instead of coming by the natural route across the medium, has to travel up the row of cells, across the top conducting piece, and then down the thin wire.

§ 13. In all these cases matters are somewhat complicated by the circumstance that in the form of circuit chosen the energy paths complex in form. We will, therefore, consider another circuit of different shape, so chosen that the energy paths will be simple. Imagine a sort of voltaic pile, made up of alternate pieces of zinc, copper, and moist conductor, these pieces being in the form of round discs with a central hole. When piled upon one another they will form a hollow column. Suppose the bottom to be closed by a plate of zinc and the top by a plate of copper, and a thin wire to be connected from the middle of the top plate to the middle of the bottom one. We shall then have a complete circuit constituted by the cylindrical battery outside and the wire inside. According to the

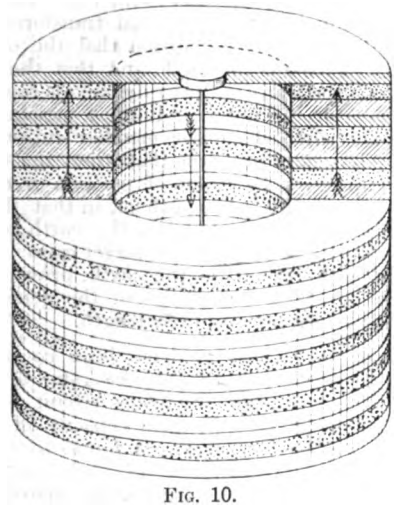

Fig. 10.

hydraulic hypothesis, there will be a current propelled up the cylindrical pile, across the top plate and down through the central wire, as in Fig. 10, and energy will travel by the same route, being pushed along the wire, and heating it as it goes. According to the modern and rational view, the energy which is set free at the surface where the zinc is attacked by the acid will simply flow radially inwards in all directions to the wire, just enough going to any given part of it to keep up the radiation of heat from that part. Fig. 11 gives a sectional view of the supposed arrangement. The energy paths being straight across from the cells to the wire, have not been drawn in as in some of the preceding figures.

§ 14. Before proceeding any further, I pause to consider some of the *à priori* objections raised by Mr. Sprague to the notion of energy paths through the medium.

In § 6, p. 514, Mr. Sprague says:—"That is the essential characteristic of electric energy, that it is linear, and controlled in direction as distinguished from the energy of heat and light, which are radiant, though even they can be to some extent controlled in direction." A most misleading statement. What is more certain than that in Hertz's experiments electric energy is radiant in precisely the same sense as light is radiant? And, again, in those cases where there is a steady flow of so-called current, is it always "linear and controlled in direction"? How about the spreading of currents in metal sheets, or through an earth return? I pass on to § 18, p. 576, where Mr. Sprague puts a few conundrums. He observes that, if the source, instead of sending energy into the conductor, sends it into the medium, "it follows that at every point of the circuit an amount of energy must enter the conductor sufficient to work the mechanism, be it what it may, which transmits, or is, the current." (So far, I quite agree.) "We have now to solve this problem: How does the current which does not exist attract from outside space the energy which is to produce the current and control the outside energy?" This is very nearly as wise a query as the following:—When a pull is transmitted along a chain, each link pulls at the next one; we have therefore to solve the problem, how does any one link, in which at first no pull exists, contrive to attract from the link next to it sufficient force to exert the required pull?

But Mr. Sprague proceeds:—"But the current is exactly equal at all parts. The energy needed is not equal at all parts" (I quite agree, and hold that this in itself is a ground for thinking that the path of the current is not the same as the path of the energy), "it increases in the same ratio as the capacity" (does he not mean conductance?) "of the conductor diminishes." "Problem: How does the external energy distinguish where much or little of it is wanted?" Again, I can parallel the query by one equally serviceable. The wheels of a watch do not turn at equal rates; how does each of them know how fast it is to turn? Or, again; when a river turns in a bend the water is found to run at different rates at the two sides. Problem: How does the energy needed by the water in getting up speed know where much or little of it is wanted?

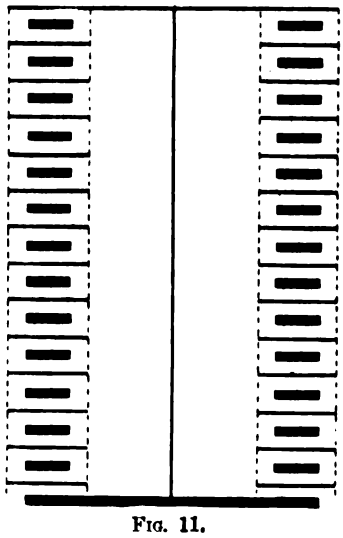

Fig. 11.

There is nothing either absurd or extraordinary in the energy proportioning itself to the requirements of the circuit; the thing that would be absurd or difficult to understand would be that the energy should not so proportion itself. Refer back to Fig. 9, and consider what would happen if one part of the thin wire should suddenly offer a greater resistance than the rest. Suppose this to happen with the piece between points 2 and 3. What would occur? Well, instantly the distribution of potential would alter itself, a fall of more than one volt occurring at this part, and a proportionately lesser fall along the other parts. As a consequence, the energy-paths would converge more densely upon this part, and less densely on the other part. To ask how the energy knows where it is wanted is simply trifling with the question.

(*To be continued.*)

THE LIGHTING OF THE CENTRAL STATION AND HOTEL, GLASGOW.

The Caledonian Central Station and Hotel, Glasgow, are now lit throughout by electricity. Brush arc lamps have, however, been running in the station for the past six years. These are of the ordinary 10 ampere type, and are suspended at a height of 16ft. above the platforms, and spaced 47ft. apart; the result being a very even and satisfactory distribution of light. The number of lamps employed over the platforms is 51, illuminating an area of 112,000 square feet; eight other lamps

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are employed at the entrance to the station and in the yards, &c.

The hotel and station buildings have just been fitted throughout with incandescent lamps by Messrs. Mavor and Coulson, the work being carried out to the specification and under the superintendence of Mr. A. S. Dunn, telegraph superintendent, Caledonian Railway Company. There are 1,300 16 c.p. lamps in the hotel, and 400 in the station buildings, &c. The mains are carried in heavy casing, let into the wall of the luggage hoist. Each floor is fed by separate mains, and thus heavy T joints and main fuses are avoided in the building. The mains are brought into distributing boxes in the corridors, and are connected each with a copper bar of L section, which is mounted on a slate base. Facing the bar a number of short contact pieces of the same section as the bar are fixed, and to these pieces the ends of the distributing conductors are attached.

In the distributing box the connection between the bar and the contact pieces is made by means of a fuse mounted between two copper springs, which are attached to a porcelain block. The block is made to push tightly in between the bar and the contact, the copper springs pressing against them. Except in a few special cases, there are no other fuses on the branches to the lamps but those just described. The conductors leaving the fuse contacts are of 7/21½ cable, and this is carried right down to lamps and switches. Where flexible cord is used this is of 225/40's, so that in no case is a fuse necessary in the ceiling connections or switches. Six or eight lamps are supplied from each 7/21½ cable. In some cases the number of lamps at a considerable distance from the first distributing box is such that it would not have been convenient to run a sufficient number of 7/21½ branches to feed them. In these cases one or more pairs of fuse terminals are provided in the first distributing box, and a pair of suitable cables run from them to a second distributing box, whence the distribution is effected by means of 7/21½ cables. This system has been employed by Messrs. Mavor and Coulson since 1885, and it is now the general practice of the firm to use nothing smaller than 7/21½ cable, or the equivalent of No. 14 B.W.G., for switch and lamp connections.

A good effect and efficient illumination is produced under the railway bridge in Argyle-street. The portion of the street is 140ft. × 60ft., and nine 200 c.p. Sunbeam lamps are used with 18in. enamelled iron reflectors above them. The supports for these lamps are hung from spiral springs, to avoid possible breakage of filaments by the vibration produced by trains.

The generating plant occupies some of the arches upon which the station is built. Steam is taken from a range of Lancashire boilers, which also supply the laundry-heating apparatus, &c. The pressure is 50lb. in the square inch. The motive power consists of two single cylinder engines and one larger engine. The two smaller engines have been built by Messrs. Fullerton, Hodgart, and Barclay, engineers, Paisley. They are fitted with trip valve gear. The governor mechanism is disconnected from the valve gearing, and is free to adjust itself accurately to the load until the moment when the trigger engages with the motion rod. Its action is, therefore, undisturbed except by the unavoidable friction of its own working parts. The larger engine has been converted by the same firm, a similar trip gear and governor being employed to operate grid valves, working on the back of the ordinary slide valves, and at right angles to them. The arrangement gives complete satisfaction. Each of the three engines drives by band a separate section of shafting. The ends of the sections are fitted with couplings, but are left uncoupled under normal working conditions. The dynamos for the glow lamps are by Crompton and Co. There are two 38 kilowatt machines and one 20 kilowatt machine. The switch-board is arranged so that the engineers in charge is able to ascertain the current passing to any circuit, and to distribute the load among the dynamos as he may wish. Sir William Thomson's voltmeters and current gauges are employed. Switch-board, switches, &c., have been designed, and the whole of the work carried out under the supervision of Mr. W. B. Sayers, Messrs. Mavor and Coulson's manager.

ON SOME EFFECTS OF ALTERNATING-CURRENT FLOW IN CIRCUITS HAVING CAPACITY AND SELF-INDUCTION.*

BY DR. J. A. FLEMING.

(Concluded from page 77.)

22. Reference has been made recently in a Paper read by Major Cardew to the difference of electric condition as regards potential above the earth which will exist between two insulated conductors one of which entirely encloses the other, and which have different capacities, when they are connected to the terminals of an insulated transformer or alternator. In the case of a concentric cable the two copper members of which are insulated from each other, and the outer one insulated from a metallic sheath connected to earth, we have two insulated conductors, the interior one having capacity with reference to the outer, but not with reference to the earth, and the outer one having capacity both with reference to the inner and also with respect to the earth. This last capacity is generally, in cables as actually made, very much greater than the former.

In the case of the Ferranti trunk mains, the inner-to-outer capacity is, as we have seen, about one-third of a microfarad per mile run of the cable. Calculating from the measured dimensions, and from the specific inductive capacity of the insulating material as deduced from the inner-to-outer capacity, the magnitude of the outer-to-earth capacity I find to be about ten times greater, or more than three microfarads per mile. It follows immediately, from elementary principles, that the two insulated members of such a concentric cable will, when connected respectively to the terminals of an insulated transformer or dynamo, always be brought into such a condition that the outer member is at zero-potential as regards the earth, and that the full difference of potential which the transformer or dynamo is capable of making will subsist between the outer and inner member of the cable. This is true only when the outer member entirely encloses the inner member; but it is also true that when the two conductors have different capacities, by reason of position or form, there will be an electrical inequality between them, in that the difference of potential between each conductor and the earth will not be the same. The conductor which has the larger capacity will have the lesser potential with respect to the earth, provided always that both conductors attached to the poles of the generator or transformer are insulated throughout their length.

23. The condenser effect we have been considering, and in particular the alteration of the change ratio of a transformer which takes place when its secondary circuit is connected to a conductor system having a certain capacity in relation to the inductance of that secondary circuit, is found to operate in many curious ways in the practical use of such combinations. For instance, if a pair of alternators separately excited are working in parallel on an omnibus main leading to a conductor system of no sensible capacity, then we know very well that if the dynamos are synchronised, and contributing equally to the outgoing current, the method adopted to take one dynamo out of circuit would be to lower its exciting current, and when its outgoing current fell to zero to sever its connection with the omnibus main. If, however, the alternators are working through step-up transformers, and into a conductor system consisting of concentric cable, it is found by experience that the exciting current of the dynamo to be taken out must be raised, and not lowered, in order to bring it into a condition in which it can be cut off from the omnibus main without dangerous sparking at the switch; and, conversely, in putting it into parallel the incoming alternator has to be excited to a lower electromotive force than is necessary to maintain the standard potential difference at the terminals of the step-up transformer before putting it into connection with the omnibus main. This is obviously due to the fact that the change ratio of the step-up transformer is altered by the very act of putting it into connection with the conductor system, and hence the excitation of the alternator at the moment of making or breaking connection with the main must be such as will bring the potential difference of the free secondary terminals of the step-up transformer to a value equal to the potential difference of the two points on the conductor having capacity to which they are about to be connected, or from which they have just been severed; and when the connection of the alternator is made, the excitation can be altered to divide the load on the machines properly. This, of course, would not be case if high-tension alternators of very small inductance were set to work in parallel on such a concentric conductor system. In this case the condenser effect is practically nothing, and the behaviour of the machines on going into or out of parallel would present nothing unusual.

* Paper read May 7, 1891, before the Institution of Electrical Engineers

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24. In the cases briefly discussed above, the cables, whether concentric or simple, have been found to act as single condensers substituted for them would act; and in the experiments described no progressive rise of pressure from one end to the other of a cable possessing capacity was found to exist.

It is, however, quite possible for self-induction, resistance, and capacity to be so combined together in one conductor that the action of an impressed periodic electromotive force at one end will create a progressive rise of mean pressure along the cable when the far end is insulated. The complete theory of such effect is rather too long to discuss here. The propagation of a simple periodic current and the action of a simple periodic electromotive force upon a concentric cable has been very fully discussed by Mr. Oliver Heaviside in an able series of papers on "The Self-Induction of Wires," published in the *Philosophical Magazine* for 1886 and 1887. A very brief summary of the results is all that can be given here; but those desirous of further information may be particularly referred to *Philosophical Magazine*, Vol. XXIII., January, 1887, page 18, in which paper Mr. Heaviside deals with the problem which is particularly the practical one — viz., a concentric cable having at one end a transmitting apparatus, such as a telephone, alternator, or a step-up transformer, and at the other a receiving instrument, such as another telephone or a step-down transformer.

We have, then, a sending instrument having resistance and inductance; a cable having resistance, capacity, and inductance; and a receiver having also resistance and inductance. Given the electromotive force in the transmitter, the problem is to find the current in the receiver.

Consider, first, a very long concentric cable having inductance L, resistance R, and capacity C, all per unit of length. Fix attention upon a small length of the cable, δx, and suppose that the current flowing into this element at any instant is i, and the current flowing out of it is $i - \delta i$ when some electromotive force acts at one end of the cable. Also, let v be the potential of the inner conductor at the one end of the element of length, δx, and $v - \delta v$ be the potential at the other end: then the current, i, at any instant, t, is determined from the fundamental equation,

$$L\,\delta x\frac{d\,i}{d\,t}+R\,\delta x\,i=\delta\,v \quad . \quad . \quad . \quad . \quad (33),$$

and the current and potential are connected by another relation,

$$\frac{d\,i}{d\,x}=C\frac{d\,v}{d\,t} \quad . \quad . \quad . \quad . \quad . \quad . \quad (34),$$

because the current flowing out of the element of length is less than the current flowing into the element by the condenser current taken up in the element.

Differentiating (34), and substituting in (33), we arrive easily at the equation,

$$L\,C\,\frac{d^2\,v}{a\,t^2}+R\,C\frac{d\,v}{d\,t}=\frac{d^2\,v}{d\,x^2} \quad . \quad . \quad . \quad . \quad (35).$$

This differential equation gives us the means of determining the potential, v, at any time and place in the cable.

Let v_0 be the electromotive force at the origin or the end of the cable at which the dynamo or electromotor is applied, and let V_0 be its maximum value—such that,

$$v_0=V_0\sin p\,t:$$

then, if the cable is infinite in length, the solution of the equation (35) can be obtained, and the potential, v, at any distance, x, from the origin, and any time, is easily shown to be given by

$$v=V_0\,e^{-P\,x}\sin\,(p\,t-Q\,x),$$

where the quantities P and Q are—

$$P=\pm\left\{\frac{p\,C}{2}\left(\sqrt{R^2+p^2\,L^2}-L\,p\right)\right\}^{\frac{1}{2}}.$$

and

$$Q=\pm\left\{\frac{p\,C}{2}\left(\sqrt{R^2+p^2\,L^2}+L\,p\right)\right\}^{\frac{1}{2}}.$$

For the Ferranti trunk mains the values of these quantities have been calculated in Section 14.

If the cable is not infinite in length, but has a finite length, l, then two cases may be considered—(i.) when the cable is short-circuited at the far end, and (ii.) when its two members are insulated or open-circuited at the far end.

Taking the first case of a concentric cable of length l, short-circuited at the far end, and attached to an alternator of negligible inductance and resistance at the other, Mr. Heaviside has shown how the potential at any distance, x, from the machine can be obtained, and also the current flowing through an ammeter placed at any point in the cable. If V_0 is the maximum value of the periodic electromotive force applied at the dynamo end, and v is the potential at any time, t, and any distance, x, from the dynamo end, then he gives the value of v as

$$v=V_0\,e^{-P\,x}\sin\,(p\,t-Q\,x)$$
$$+V_0\,\frac{e^{P\,x}\sin\,(p\,t+\theta_2+Q\,x)}{e^{P\,l}(e^{2\,P\,l}+e^{-2\,P\,l}-2\cos 2\,Q\,l)^{\frac{1}{2}}}$$
$$-V_0\,\frac{e^{-P\,x}\sin\,(p\,t+\theta_2-Q\,x)}{e^{P\,l}(e^{2\,P\,l}+e^{-2\,P\,l}-2\cos 2\,Q\,l)^{\frac{1}{2}}}$$

(see *Phil. Mag.*, Vol. XXII., September, 1886, p. 284.)

It can be shown from the above that the ratio of the maximum value, V, of the potential at any distance, x, from the origin, to the potential at the origin, V_0, is given by the relation,

$$\left(\frac{V}{V_0}\right)^2=\frac{e^{2\,P\,(l-x)}+e^{-2\,P\,(l-x)}-2\cos 2\,Q\,(l-x)}{e^{2\,P\,l}\quad+e\quad-2\cos 2\,Q\,l} \quad . \quad (36).$$

In the above equations P and Q stand for the functions of resistance, inductance, and capacity given above in Section 14, and e is the Naperian base.

The equation (36) enables the pressure at any point in the cable, as given by a voltmeter, to be predetermined from the pressure at the origin. The current flowing through a low-resistance ammeter placed at any point in the cable can also be deduced from the equation (36), and its maximum value, I, is shown by Mr. Heaviside to be given by the equation,

$$I^2=\frac{V_0^2\,C\,p}{\sqrt{R^2+p^2\,l^2}}\,\frac{e^{2\,P\,(l-x)}+e^{-2\,P\,(l-x)}+2\cos 2\,Q\,(l-x)}{e^{2\,P\,l}\quad+e^{-2\,P\,l}\quad-2\cos 2\,Q\,l} \quad . \quad . \quad (37).$$

This gives us the value of the dynamometer reading at any point in the cable. It shows us that if l is great enough the current flowing through an ammeter placed at the distant end of the cable would be zero.

Suppose, next, that the distant end of the cable is open-circuited, and that an electromotive force, of which the maximum value is V_0, acts at the home end. It is then possible to prove that under these circumstances the ratio of the maximum value, V, of the potential at any distance, x, from the origin to the maximum value of the potential at the origin, is given by the equation,

$$\left(\frac{V}{V_0}\right)^2=\frac{e^{2\,P\,(l-x)}+e^{-2\,P\,(l-x)}+2\cos 2\,Q\,(l-x)}{e^{2\,P\,l}\quad+e^{-2\,P\,l}\quad+2\cos 2\,Q\,l} \quad . \quad . \quad (38).$$

If $x=l$—that is, if we consider the potential at the far end, the numerator of the right-hand side becomes equal to 4, and hence if the denominator is numerically less than 4 for any given cable—it indicates that a progressive rise in pressure along such cable will take place from the machine end to the free or insulated end.

In a very able Paper in the *Philosophical Magazine* for January, 1887, p. 21, Mr. Heaviside has attacked the general problem of calculating the current flowing through a transformer at the far end of a concentric cable when an alternator or transformer giving a periodic electromotive force of maximum V_0 is placed at the other. The Paper is not an easy one to read, and was probably still harder to write. Some of the general results are, very briefly, as follows:— If L_0 and R_0 are the total inductance and resistance of the transmitter, whether alternator or transformer, and L_1 and R_1 the same quantities for the receiver, and L, R, and C the inductance, resistance, and capacity per unit of length of the cable, and V_0 the maximum value of the impressed electromotive force at the transmitter, and C_0 the maximum value of the current through the receiver, then

$$C_0=2\,V_0\frac{C\,p}{(R^2+p^2\,L^2)^{\frac{1}{2}}}\left[\begin{matrix}G_1G_0e^{2\,P\,l}+H_1\,H_0e^{-2\,P\,l}\\-2(G_1G_0H_1H_0)^{\frac{1}{2}}\cos 2(Q\,l+\theta)\end{matrix}\right]^{-\frac{1}{2}},$$

where G_1, G_0, H_1, H_0, and θ are complicated functions of the resistances and inductances of the receiver and transmitter, and which have the values,

$$G_0=1+(P^2+Q^2)\left(\frac{I_0}{I}\right)^2+(2\,P\,R+2\,Q\,p\,L)\,R_0+$$
$$(2\,P\,L\,p^2-2\,Q\,p\,R)\,L_0;$$
$$H_0=1+(P^2+Q^2)\left(\frac{I_0}{I}\right)^2+(2\,P\,R+2\,Q\,p\,L)\,R_0-$$
$$(2\,P\,L\,p^2-2\,Q\,p\,R)\,L_0;$$

and similarly for H_1 and G_1.

I_0, I, and I_1 are the impedances of the transmitter, cable, and receiver; and the quantities P and Q have the values given in Section 14.

The quantity θ is an angle which is determined from the expression,

$$\tan 2\,\theta=\frac{2\,(A\,b-a\,B)}{A^2+B^2-(a^2-b^2)},$$

where

$$A\,b-a\,B=(R_0+Q_1)\,(R\,Q-L\,p\,P)+(L_0+L_1)\,p\,(R\,P+L\,p\,Q)$$
$$-(R_0\,I_1^2+R_1\,I_0^2)\,C\,p\,P-(L_0\,I_1^2-L_1\,I_0^2)\,p^2\,C\,Q;$$
$$A^2+B^2=I^2+C^2\,p^2\,I_0^2\,I_1^2-2\,(R_0\,R_1-L_0\,L_1\,p^2)\,L\,C\,p^2$$
$$-2\,(R_1\,L_0+R_0\,L_1)\,p^2\,R\,C;$$
$$a^2+b^2=(P^2+Q^2)\,[(R_0+R_1)^2+p^2\,(L_0+L_1)^2].$$

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The question whether the mean pressure at the receiver is greater than the mean pressure at the sending end, or less, will in general depend upon the sign of tan 2 θ.

The quantities G_0 and H_0 become equal to unity when the inductance and resistance of the sending instrument are zero or very small.

The practical deduction which may be made from the above investigation is, that when the alternator at the sending end has very small resistance and inductance, the pressure at the receiving end of the cable will be less than the pressure at the transmitting end, for almost any cases which occur in practice; but this is not always the case when the transmitting instrument has a sensible inductance. We may then have conditions under which there is a progressive rise of pressure from the sending to the receiving end.

The time at disposal has not permitted me to do more than sketch out the general results of such investigations as have been made on the propagation of periodic currents through conductors having sensible capacity and inductance. These investigations need to be brought into further comparison with the results of experience, in order that we may see how far they agree with observed facts, and how far they can be trusted as a guide in predicting the results of the application of known electromotive forces to conductor systems in which the capacity and inductance can be predetermined.

ON SOME POINTS CONNECTED WITH MAINS FOR ELECTRIC LIGHTING.*

BY WILLIAM HENRY PREECE, F.R.S., PAST-PRESIDENT.

1. I do not purpose in the following Paper to describe the mechanical details of the various systems of mains adopted in different places to transfer and distribute electrical energy. These most of us can see for ourselves by personal inspection in the various works now in progress in London, or can read about at our leisure in the numerous Papers that have been recently printed in the technical periodicals and in the *Journal* of our Institution. My object is to extol the "sweet simplicity" of the two-wire system, the practical security of concentric mains, and the unquestionable economy of the high-pressure principle. At the same time, I do not want to be considered an advocate of any one particular method. Engineering works must necessarily be considered a species of compromise. Conditions vary in different localities; difficulties arise in the most unexpected quarters; different ways of surmounting obstacles occur to different minds. What is good for one place need not necessarily be good for another. The independent engineer must keep his mind open; he must master his requirements; he must give every plan his consideration, and choose his best agents, despite the tyranny of the Patent Laws and the susceptibility of inventors. He must, however, be just, and see that merit is awarded and claims respected.

2. I do not intend to discuss overhead wires. I consider them, for high-pressure electric light circuits, an abomination, especially as it is easy to show that ultimate economy is in favour of the underground system. It is only the first capital expenditure that favours overground mains; safety, freedom from accident, ease of repair, and renewals are all the other way.

3. Broadly, the different underground systems in use may be classed into those which are *fixed* and those which are *movable*.

As a type of the first, I will instance the Ferranti concentric mains, that are buried solidly in the roadways, embedded in asphalte in wooden troughs, and which are inaccessible except by excavation; and as an example of the second, I will take the ordinary telegraphic method of burying cast-iron pipes, with occasional boxes, in and out of which cables new and old can be drawn at pleasure, and where the conductors are always accessible for the rapid removal of incipient faults should they develop themselves, and removable for enlargement should the system grow.

4. Again, we must divide the systems into *high* and *low pressure*, for under these two heads we have to consider not only the all-important questions of insulation and of finance, but those of security to person and to property. The line of demarcation between high and low pressure has been defined by the Board of Trade to be 300 volts; but in what follows whenever *high pressure* is mentioned about 2,000 volts is meant, and *low pressure* implies about 100 volts. There is one case only in this country where *extra high pressure* is used, and that is by Mr. Ferranti, whose adoption of 10,000 volts is regarded by so many with fear and horror. This voltage is, however, going to be exceeded this summer by the Exhibition authorities at Frankfort, who are going to draw 300 H.P. from the river Neckar, at Lauffen, 112 miles away, by a pressure of 27,000 volts.

* Paper read May 7, 1891, before the Institution of Electrical Engineer

5. The only limit to the use of extra high pressures, or to the voltage employed, is the efficiency, economy, and durability of insulating materials.

First and cheapest on the list is *air*, which, when dry, is the most perfect insulator known—its specific resistance being, in fact, immeasurable—which has the lowest specific inductivity, and therefore is taken as unity, but which cannot resist electric stress, and through which the sparking distance has a very poor figure of merit. The breakdown stress, or sparking distance, of dry air at ordinary atmospheric pressures may be taken to be for—

Direct currents	9,200	volts per centimetre;
Periodic alternating currents ...	6,000	,, ,,

between a disc and point.

Air is, moreover, hygroscopic, and very variable in its qualities; but there is no evidence that the variation of its saturation point affects its resistance or its inductivity, excepting that it tends to coat with moisture glass, porcelain, and other insulating supports, which are essential to keep up metallic conductors in position when it is used as an insulator, if their temperature falls below that of the air. The use of air was inaugurated by Mr. Crompton in Kensington, and his example has been followed by Latimer Clark, Muirhead, and Co. in St. James's, by Prof. Kennedy in Westminster, and by Prof. Robinson in St. Pancras. It has also been followed in Paris and in Germany.

6. *Gutta-percha* has been used almost exclusively for submarine cables, and for telegraphic underground wires in Europe; but owing to its scarcity and its high price it is rapidly being replaced by other materials, and, excepting in Paddington (Great Western Railway), where it was laid down by the Telegraph Construction Company, I do not know of its use for electric light purposes. It does not stand exposure to variations of temperature or of dryness. It is durable only in water, and even if it were plentiful it is doubtful if it were practical for electric light purposes.

7. *India Rubber* is more practical. Modern improvements in vulcanisation have brought it within the scope of the engineer and the range of finance. The addition of a small quantity of sulphur, subjected to high temperature, produces a new form of rubber, which makes not only an admirable insulator, but a waterproof, homogeneous, compact, and apparently durable compound. Our experience of this latter quality is, however, limited at present. The cables of this class manufactured by the Silvertown Company have justly acquired a high reputation, though several other firms are competing with them on equal merits. The weak point is in the jointing, which, unless properly done and thoroughly vulcanised, admits into the system numerous points of danger, which, sooner or later, will occasion engineers in charge many minutes of anxiety and worry. Compound rubber cables are used exclusively by the Metropolitan Electric Supply Company and by the House-to-House Electric Light Company, for their mains distributing high-pressure alternating currents. I am assured by both companies that up to the present time not one single defect has developed itself in their mains.

8. *Bitumen* is a mineral product of a pitchy character, imported into this country principally from Trinidad. The late Lord Cochrane tried hard to introduce it as an insulating medium, but it remained for the enterprising firm of Callender to make it a real commercial commodity. When purified, refined, and vulcanised it makes, combined with some vegetable fibre like jute, a tough elastic coating, proving it to be an active competitor of compound rubber. When used in its crude state it forms a solid mass, in which the more refined "bittite" can be embedded in an immovable and apparently indestructible and unassailable bed.

9. There are various waxes—*paraffin*, *ozokerit*, and other hydrocarbons—which have a high specific resistance and a low specific inductivity, that have been much used; but the most practical use of these materials appears to be their combination with brown paper, which has been introduced by Mr. Ferranti in his Deptford mains.

10. The refuse of crude *petroleum*—that is, petroleum after all the spirits, illuminating and lubricating oils, and waxes have been distilled or expressed—a thick, heavy black mass, liquifiable under high temperature, but almost uninflammable, and eminently adapted to resist high temperatures—makes an admirable insulating compound of very high specific resistance and comparatively low specific inductivity. It is the material used by the Fowler-Waring Company, and destined to enjoy a profitable career.

11. *Heavy resin oil* is an admirable insulator, filling, when hot, all the pores of vegetable matter, like jute and cotton, immersed in it, excluding all air and moisture from the conductor, having a very high resistance and a very short sparking distance, but, above all, being viscid and movable, so that any puncture is at once filled up by its own mobility, so that any fault occasioned by piercing is instantaneously self-cured. Oil has such excellent merits that it has been proposed by Johnson and Phillips to bury in it high-pressure

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alternate-current transformers. Heavy oils discard water, owing to their density. They are inoxidisable, and, therefore, practically indestructible. Many failures in the use of oil as an insulator in the past have arisen from the use of oils of too low specific gravity.

12. There is one objection to most of these mineral hydrocarbons, viz., that they require to be encased in lead; but oil has this advantage—that it can be used in iron pipes in the method adopted by Brooks. Lead covering is expensive, and it adds seriously to the weight of the cable, so as to render more difficult its handling and drawing in and out. On the other hand, lead adds materially to the life of the cable. I have in my possession samples of lead-covered wire which were buried in 1844, and in which the conductor and insulating medium are now as perfect as when made. Lead, however, in some localities, especially in decaying vegetable matter, is itself attacked. When, however, properly protected, it ought to last for centuries. The lead used by the Romans to distribute water in Pompeii is still visible. Lead-covered cables are very largely used in America, Germany, and France, and their employment is rapidly extending in England.

13. All these materials, excepting air, are equally applicable for high and for low pressure: the thickness only has to be increased with the pressure; but we have yet to know what influence the rapid reversals of high-pressure alternating currents have upon the molecular structure of the material. The difference in the striking distance in air shows that the stresses in the two cases of direct and alternating currents are very different. Time alone will give us the experience we want as to the effect of these stresses on the texture of the dielectric used. It is this absence of experience that causes so much want of confidence in the use of extra high pressures.

14. The operation of Sir William Thomson's law, the relative economies of the two-wire, three-wire, and five-wire modes of distribution, the comparative cost of high and low-pressure, have been so frequently discussed, and are so thoroughly well-known, that they need no description here. Everyone will admit that as we increase the pressure driving the currents, we can diminish the size of the conductor; and although we have to increase the relative thickness of the insulating medium the actual quantity used remains practically the same. Hence, high-pressure means great economy in copper. The future of electric lighting is a financial question; its practicability and efficiency are beyond doubt. The lion share of the capital necessary for the extension of electric lighting over a district is required for the mains and conductors; an important item in working expenses is in their maintenance. Hence this is now the field for the exercise of economy. If we can reduce the cost of distribution and its up-keep by 50 per cent., we should be able to supply light by electrical energy more cheaply than by gas. It is a pity that some of that redundant mental energy which is endeavouring to raise the efficiency of dynamos and transformers from 94 per cent. to 95 per cent. could not be transferred to the question of mains, where real advancement and true economy on a considerable scale are much more required.

In Liverpool, Birmingham, and Bradford, low pressure is distributed by the original and simple two-wire parallel system. In Kensington and Westminster low pressure is distributed by the three-wire plan. The London Electric Supply Company, the Metropolitan Company, and the House-to-House Company distribute their high-pressure systems by two wires; but in Rome, where sub-stations are used, the distribution of low pressure is by three wires. In Germany distribution in some places is by five wires, and I have heard it mooted to distribute in Paris by six wires.

15. The points that determine the distribution of low pressure are fall of potential and number of feeding points and distributing stations. We need not consider the heating of conductors. If we take care of the potentials the waste will take care of itself.

One ton of copper of one square inch sectional area covers a length of 192·3 yards, and its resistance is ·0046 ohms. Hence, a length of 220 yards weighs 1·13 tons, and its resistance is ·00527 ohms. A pair of such mains will weigh 2·26 tons, and their resistance will be ·01054 ohms. 1,000 amperes means, therefore, a loss of 10½ per cent. (and one kilowatt is wasted in every 43·4 yards), 500 amperes means a loss of 5¼ per cent., and 237 amperes means a loss of 2½ per cent., in such a circuit when the full load is supposed to be concentrated at the end. If we take a fall of potential of 2½ per cent. in each main, which is the recognised maximum waste at full load allowed to comply well with Thomson's law, it means 474 amperes delivered at 100 volts, or 1,600 8 c.p. lamps served. In fact, we may say that two mains of one square inch copper will serve 1,600 8 c.p. lamps at 220 yards distance; and this appears to be the commercial limit of the two-wire low-pressure distribution. Of course, if we are content to admit a greater waste, this limit of distance can be extended, and the number of lamps to be served can be increased in the same ratio. The exact waste to be allowed is an economical question, governed a good deal by the conditions of the problem, financial as well as engineering. Now, if we add another 100 volts at the point of supply, we can deliver the same energy for the same number of lamps with the same loss, at 880 yards; and for every additional 100 volts delivered, we can extend the distance to which the supply can be driven under similar conditions, as the square of the unit distance, 220 yards, for to maintain the same energy the current is *diminished* in the same ratio. Thus, 2,050 volts will drive the energy required for 1,600 8 c.p. lamps 50 miles if we use mains of one square inch sectional area, and are satisfied to waste only 5 per cent. of the driving energy. Prof. John Hopkinson, F.R.S., showed how,* by the use of an intermediate third wire and two dynamos, we could use 200 volts with our present lamps, and therefore we could practically diminish for the same distance the weight of copper used by one-half, or we could make the same weight of copper serve double the distance. The third wire, however, diminishes the effective economy of the plan. Its practical commercial limit appears to be about half a mile; and its disadvantages to be, more dynamos to work, and considerable complication to adjust and regulate the equilibrium of lamps on the circuit.

The five-wire system, which is in use in Germany, enables us to use 400 volts at the point of delivery; and this, again, enables us to extend our area of supply, with the same weight of copper, to one mile, but with more dynamos, and with more regulation and balancing, and, therefore, with more complication.

There is no practical limit to the high-pressure system; 10,000 volts will drive energy from Deptford to London on two mains of one-quarter square inch section to serve 50,000 lamps; and 27,000 volts will drive 300 H.P. 112 miles, from Lauffen to Frankfort, on a conductor of ·06 square inch sectional area, *i.e*, a No. 2 copper wire.

16. But we have to take into consideration the difficulties of the distribution.

On the two-wire system this means one central station for each effective area having a mean radius of 220 yards. On the three-wire system this area can be extended to a mean radius of one-half mile; the five-wire system extends the mean radius to one mile; but with the high-pressure system the area is practically unlimited in extent. When the mains and feeders are at high pressure, and the distribution at low pressure by two wires, we must contemplate *sub-stations* serving areas having a radius not exceeding 220 yards, if the lamps be uniformly scattered over the area and our waste energy is kept low.

A transformer sub-station is a very simple and cheap structure. It may be excavated underground, or be in a cellar, or in a back-yard. The instruments are stationary. They require no oiling, nor adjusting, nor handling, nor even tending. They can be buried in oil and suffer no deterioration. They are simple in construction, and should need no repair. Switches to throw them in and out of circuit may be automatic or manual, and can be operated from outside the transformer room, as is done in Rome.

17. The sub-station high-pressure system has been thoroughly worked out in Rome. Every nest of about 2,000 lamps is served from a sub-station containing a bank of 12 transformers, each of 7½ kilowatt capacity. Means are provided to cut transformers in and out as the load comes on and off. The great waste of the idle transformer is thus prevented, and by banking them in this way only half the total number of transformers is required. Moreover, it enables the most efficient transformers to be used, and always at full load. It is well known that the efficiency of a transformer increases with its size. Mr. Ferranti has already reached 100 kilowatts without reaching a limit to this law. Distribution by two wires on this limited scale is of the most economical and effective kind, and there is no complication of adjustment of current or regulation of pressure. Each sub-station serves, as a rule, in Rome, one block of buildings, so that generally the high-pressure mains alone are underground. The pressure is 2,400 volts. The distribution in Rome is by three wires—not, however, for any economical reason, but simply to allow arcs and glow-lamps to work on the same network without interference and without waste. The counter electromotive force of the arc prevents arc lamps from being registered accurately on any of the existing meters, but the three-wire plan enables the arcs to be served separately from the glow-lamps. Arc lighting is in great request in Italy, especially for shop-lighting.

The chief difficulty the engineer has to encounter is to know his users and the extent and character of the supply. This is now generally guesswork. It is difficult to estimate the actual load factor. We have to take the gas supply as our criterion, and to judge of the probability of obtaining customers from the character of the residents and occupants of the district.

18. It is impossible to serve economically a wide and scattered district with a mean radius of over one mile by any other means

* John Hopkinson, Patent No. 3576, July, 1882.

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than by high pressure, for we cannot multiply central stations without seriously increasing capital outlay and working expenses; unless, indeed, the density of supply be very great, as it is in some quarters in London and in some of our large provincial cities.

19. Let us assume that we have a wide and scattered district to serve, and that we are going to supply at high pressure, and to distribute by two wires from sub-stations: the problem we have to solve is, what shall be the character of the high-pressure mains and feeders connecting the central station, or stations, and the sub-stations?—shall they be separate conductors or concentric cables? We will also assume that the weight of copper and quality of insulation is the same in each case, and that their prime cost is

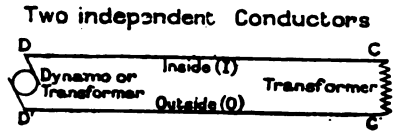

Fig. 1.

Fig. 2.

not materially different, although, as a matter of fact, for the same distance the concentric main, if made of the same materials, costs less than the two separate conductors.

It is, therefore, a question of *adaptability*, *security*, and *freedom from disturbance*. To study these points we want to know how the potentials are distributed on such conductors.

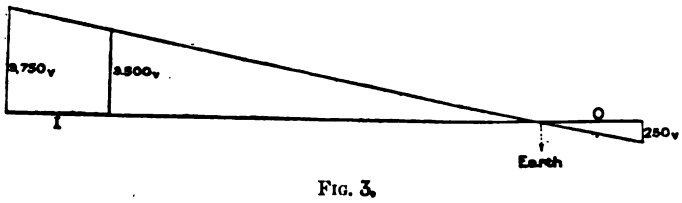

Fig. 3.

If we consider two independent conductors (Fig. 1), lying side by side in the same pipe, or conduit, connecting the two poles of the dynamo, D and D', with the transformer, C C', and we call the *go* wire the *inside* (I) and the *return* wire the *outside* (O)—then, if we represent the effective resistances at any moment of the transformer by the straight D D' line (Fig. 2), D C can represent the resistance of the inside conductor, C C' that of the transformer,

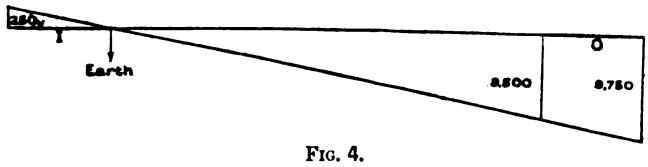

Fig. 4.

and C D' that of the outside conductor. If the ordinate D *d* represents the positive pressure when at its maximum and the transformer on full load, then, if the pole D' be connected with earth, the slope of the line will indicate the simultaneous pressure at any point of the circuit, and the difference between the ordinates will give the fall of potential between any two points; that is, there is

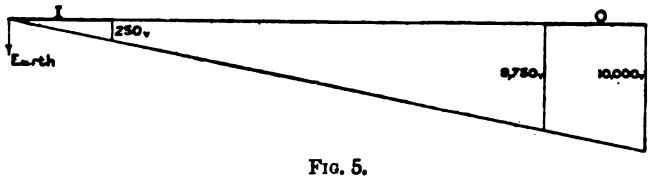

Fig. 5.

a fall of 250 volts in each conductor, and if the circuit be carrying 50 amperes there will be a waste of 12,500 watts in each conductor. If the line O were in its proper position and direction alongside I, as in Fig. 1, it would be seen that the difference of potentials between any contiguous points is everywhere 10,000 volts.

Now, if the earth be transferred from D' to the negative pole of the transformer, C', the pressure at the similar phase will rearrange itself as shown in Fig. 3; and Figs. 4 and 5 give the same information when the earth is consecutively fixed at the other pole of the transformer and dynamo. Fig. 6 shows the distribution when the centre of the transformer is to earth, or when there is no earth.

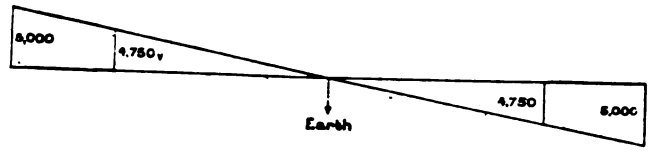

Fig. 6.

It will be seen in each case that the fall of pressure remains the same; the difference between the potentials between the conductors remain the same: it is the sign and the difference of potential between each point and the earth that has altered. Fig. 7 shows the distribution when the transformer by some accident is disconnected, and Fig. 8 when it is short-circuited.

I have not considered the variations of potential due to the rise and fall of the currents, and I have ignored the dynamo—the

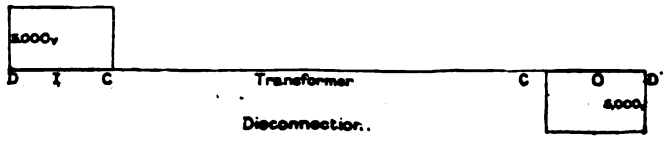

Fig. 7.

potentials being those at its terminals. Frequency, inductance, impedance, besides capacity and resistance, enter to complicate matters and to deprive the graphical method of that simplicity which is shown by the figures. But Dr. Fleming has exhaustively dealt with this subject analytically and in a masterly manner.

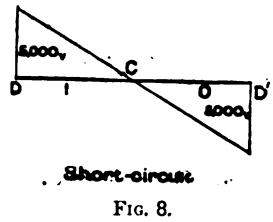

Fig. 8.

20. Now, Mr. Ferranti's mains are concentric, and their capacity must be taken into consideration. Fig. 9 shows these capacities, that between the two conductors being ·35 microfarad per mile, and that between the outer tube and earth being 3 microfarads

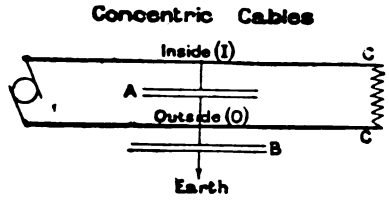

Fig. 9.

per mile. Figs 10 and 11 show the distribution of pressures when the earth is on and off the pole of the dynamo. The remarkable fact comes out that whether the pole be to earth or not the difference of potential between the outer conductor and

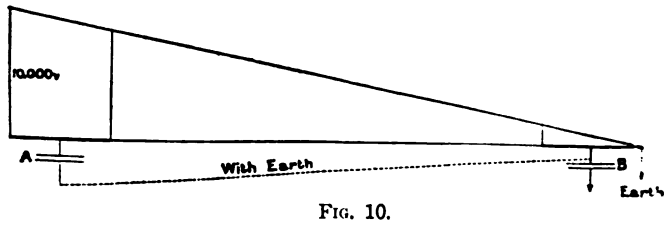

Fig. 10.

earth of a concentric cable is practically the same in each case. It does not exceed 250 volts in either case, and, therefore, the cable could be handled with impunity while the current was flowing and all connections were right, but if a fault arose—disconnection or short-circuit—then the result might be

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serious. A long length of perfectly insulated cable with considerable capacity is practically in the same position as though it were connected to earth. The surging in and out of the cable of the electrical quantity dependent on the capacity and the impressed electromotive force, produces the same effect at the terminals as the periodic flow of current through the cable when the distant end is to earth. The effect of capacity is to lower the potential, and when its magnitude is sufficient it reduces the potential of the conductor to that of the earth, for it does not allow time enough for the charge to accumulate. Hence, a concentric main, whether its outer conductor is connected to earth or not, has its potential reduced practically to that of the earth. The use of the earth is imperative to dissipate the static charge and to secure safety. A permanent and efficient earth makes the cable safe to person, and dangerous to apparatus only, which can be fully protected by fuses. Unless, however, it is most effectively applied, it may become a source of danger to person also, and of disturbance to telephones, for the existence of a variable fault might produce a shifting of potentials which would destroy the security.

It is very easy by the aid of such diagrams to study the distribution at any phase of the potential, or at any instant of flow. The capacity acts as a kind of break or damper on the currents, and its tendency is to vary the rate of rise of potential, and to flatten the curve of rise and fall of the currents. With direct and intermittent currents it acts as a fly-wheel, but with alternate currents it acts more as a spring, or as an air cushion in a hose-pipe. Its effect with ordinary frequencies is not material; but the rapid alternations of stress and displacement in the dielectric must have a tendency to heat that material. It will be readily seen how the earth dissipates the charge at once, but it also shows that when a disconnection takes place this discharge may be very unpleasant.

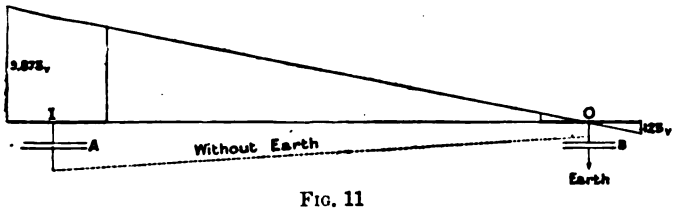

FIG. 11

(To be continued.)

SOME RESEARCHES IN ELECTRO-MAGNETIC INDUCTION.

The following is a full report of the interesting discussion which followed the reading of Mr. E. B. Vignoles' Paper on "Some Researches in Electro-Magnetic Induction," presented at the Old Students Association on Wednesday, May 13th :—

DISCUSSION.

Dr. W. E. SUMPNER said that he quite sympathised with the wish of Mr. Vignoles and his co-worker, Mr. Evershed, to put the subject in a very clear manner. An immense amount of work had been done with regard to magnetism, but there had never been any Paper which had put the subject so briefly and clearly as Mr. Vignoles had been able to do. It compared very favourably with the admirable series of articles by Mr. Evershed in *The Electrician* on transformer questions. There were one or two points, however, in which he thought Mr. Vignoles might have stated matters a little more happily. He thought he had rather confused the meaning of "line of force" with "line of induction," and had not really grasped the full value of the meaning of lines of force. Mr. Vignoles advised them to confine the idea of lines of force or lines of induction to symbols of direction and not of quantity. As had very often been explained, they could very easily be made to represent both. The direction of the line represented the direction of the force, and the density of the lines represented the strength of the force. It was also very unfortunate, especially as Mr. Vignoles pointed out very clearly the need of distinguishing between induction and induction density, that he should have represented the value of **H** in dynes, because he there assumed that magnetic force was mechanical force. Dyne was, of course, the unit of force, but it was not true that **H** was represented in dynes. **H** is not a mechanical force, any more than electromotive force is mechanical force. Each represents a mechanical force in conjunction with some unit, one of magnetism the other of electricity, but neither is a mechanical force by itself. It did not follow because the unit of magnetic force was a mechanical force on a unit of magnetism that a unit of magnetic force was a dyne. With reference to Mr. Vignoles' experiments, there was one point that he did not understand very fully. He said that he proved by experiment that the throw of the galvanometer was inversely in proportion to the resistance of the galvanometer circuit; and he then went on to show and to give a curve in which he corrects according to the resistance of the galvanometer circuit, and finds that he has to add to the throw various percentages, according to the resistance of the circuit. It seemed to him that those two statements could not be correct, and that one contradicted the other. He would like to hear from Mr. Vignoles more fully what he meant with respect to the matter. He had no doubt that Mr. Vignoles had got correct results from actual measurements. The method itself was novel in one respect—viz., that he got a throw corresponding with the complete step from one corner of the curve to the particular point which he wanted to determine. Of course, Ewing got the curves by taking successive steps and adding them together, but there was a danger of the state of the iron varying during the experiment—that is to say, while the experimenter was not noticing it the curve of induction might travel up a little bit. There was the same sort of objection, theoretically, at all events, to this method—that is, that the experimenter must keep his current in the first circuit quite constant, or he would move the corner of his curve. He thought, theoretically, that the objection to Ewing's method was the same as the objection to Mr. Vignoles' method, but that both could give perfectly good results. He did not think, however, that the method of Mr. Vignoles was necessarily a great improvement on that of Prof. Ewing. He might mention that, two or three years ago, in the laboratories at the Central Institution, a method bearing certain resemblances to this was used. The object of it was not to get the whole step from the corner of the curve to the point that was under investigation, but to get the slope of the curve at any point. In order to do that it was only necessary to determine the self induction of one of the coils for various currents flowing through the other. That gives a curve which is related to the curve of induction which Mr. Vignoles has been investigating. There was one point which ought to be clearly borne in mind, that was that in a transformer the current in the two coils is very much in excess of the magnetising current. If one wanted to determine the induction for a cycle of 10 amperes magnetising current, there must, to correspond with the transformer, be currents of 100 amperes or more in the coils. He would have liked to have heard a great deal more about those curious results which Mr. Vignoles had noticed as to the shifting of the curve along the axis of magnetic force. It was a very strange result, one which there was no theory at all to account for, and one which showed that it was impossible to apply the theoretical results, or to assume that results obtained by ordinary theory were applicable necessarily to alternating currents.

Prof. THOMPSON said that he very much appreciated the great patience, and skill, and trouble that had been taken in this research, and he was quite sure that it would bring its author great credit They ought to congratulate the author and themselves on having been the recipients of a Paper of such quality. That, perhaps, was all the more reason why he should say plainly that there were one or two little things in the Paper which he did not like at all. In the first place, he wanted to say as plainly as he could that he objected altogether to his use of the word induction for the total number of magnetic lines that passed through the iron. The word induction was used unhappily in something like half-a-dozen different senses already, and now Mr. Vignoles was going to add another. That fact was a very good reason for not using it at all. The word induction came in originally when people had the notion of action at a distance. Why should they retain the mistaken notion that electricity or magnetism or anything else was *induced* by action at a distance instead of being *produced*? The word induction, if it was retained for action apparently at a distance, ought to be kept for the production or generation of magnetism in some thing which is not in contact with, but which is at a distance from, the thing which is acting upon it. He was very sorry indeed that the word induction had ever been used for the production of magnetism through the iron itself in any one of the ways represented. He tried himself, as far as possible, to avoid its use. It was not a Paper at all on electro-magnetic induction. By the term electro-magnetic induction he always supposed was meant an induction such as Faraday discovered in the way of moving across the magnetic field. Now they were going to have it used in an entirely new sense. The other criticism was one that had already been touched upon by Dr. Sumpner—that is, the use of the conception of lines of force. He did not see why they should not use this term in a quantitative sense, as Faraday did. He begged to remark that the iron did not know the difference between the lines of induction and the lines of force. If there were **B** lines going through the square centimetre some of those **B** lines would be there if the iron was not there, and then you would call them **H**, but the iron does not remember which part is **H** and which is not **H**. Therefore, looking at the thing from the point of view of the iron, he was quite entitled simply to call them magnetic lines. Now, to come to the substance of the Paper, he was inclined to think that some criticisms passed upon Dr. Hopkinson's method were based upon an illusion. If the sketch on the board were anything more than a qualitative representation of Dr. Hopkinson's results, then the criticisms would be justified; but it did not qualitatively represent Dr. Hopkinson's apparatus at all. He did not think the author had ever seen Dr. Hopkinson's apparatus. Referring to the illustration, Prof. Thompson said that any notion that there would be serious hysteresis in the chunk of iron was simply absurd. Again, he thought far too much had been made about the question of the resistance or reluctance of the gaps. They knew how much to allow for the reluctance of the well-surfaced gap since the experiments of Ewing, and even if there were a leakage of magnetic lines at the ends, that would not affect the middle where they were making the measurement by the tenth of 1 per cent. in the actual apparatus. He did not know whether Dr. Hopkinson made any allowance for the effect of the junction in the middle, but if he did not it would be perfectly easy to do so. Ewing did not go to the zero point every time, but simply came back and supposed zero in the middle. Here he thought the author deserved great credit for having pointed out the desirability of going to the fixed point, namely, one end or the other of the cycle. He quite appreciated the importance of

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that, but he did not think they ought to overlook the fact that Ewing, though he went step by step, did take pains to check his results. He came back to approximate zero in the middle, and returned by a long jump to see if the long jump did not come to the same thing as the separate small jumps which were made in the course of the observations. In winding the rings in the way that had been pointed out, there was one point of importance that had not been noticed, that the coils ought to be wound so as to return along their own path to the place where they began. Suppose they were winding a coil on to a ring, the authors said that they wound it all round the ring. That was quite right if they wanted to take the average, but it was quite wrong if they put air-gaps into the ring. It was not enough simply to wind it round, and finish off at the place where they started. They should go on winding backwards right back again, so as to finish off where they began, to have the two ends of the coil brought out together. The reason of that was to avoid a spurious effect in the galvanometer circuit which might be due to static charge of different parts of the wire. He had himself found in certain experiments that he made that this was decidedly a thing which ought to be allowed for. With respect to the very curious irregular cycle which the authors obtained from certain specimens of iron, he might say that in certain specimens that they had examined at Finsbury they found the same sort of thing. There was one piece of iron with respect to which every group of students who got it found the same thing, that the cycle was shifted on one side. They could only account for it by supposing that that particular specimen itself remembered which way it was magnetised. He could not believe that to be consistent with the statement of the authors, that the iron did not remember which way it was magnetised, for he thought that that proved that it did. There was a reference in the Paper to Ewing's experiments on tapping, which he thought was a little beside the mark. If he remembered rightly, Ewing's results, in which he got such great alterations in the residual or permanent magnetism, related only to rods, and not to rings, and he could quite understand that there was a difference between the two. There was a very important observation, though not altogether new, which he supposed the author would admit was important, which was that a very small application of the electric current, either along the direction or at right angles to it, would take out all residual induction. Perhaps he might be allowed to refer to some old experiments of Wiedemann on that matter, and also to a very recent Paper published in *The Electrician* some few weeks ago by Dr. Finzi, where he showed that if he passed an alternating current through a piece of iron while magnetising it its effect was such that there was no residual magnetism, no hysteresis. The ascending and descending curves lay exactly on top of one another, and both of them conformed to the much abused formula of Frölich. There was another important matter, where the authors recommended large resistances in the secondary circuit. He entirely agreed that all experience showed that that was quite necessary. He would like to relate an incident with respect to that matter. He lately had a letter from the manager of an important physical laboratory asking him to explain to him a difficulty which had occurred to him, which was this: he was making experiments on rings and getting deflections, using a ballistic galvanometer, and he could not for the life of him understand how it was that it made no difference to them if he shunted the ballistic galvanometer down to the hundredth or thousandth part of the circuit. The deflection was the same when the block was in the lowest shunt, or when the block was in no shunt at all. He need not say what the reason was; it was precisely what one found with every well-built shunt dynamo in which there was very little resistance in the armature. Might he ask what the authors meant by saying that "Curve 7 exhibited in a comprehensive manner the results of the tests taking average permeability"?

Mr. VIGNOLES: As a matter of fact, we take the average curve to be the one which lies midway horizontally, that is to say, we take the average magnetising force for each value of B. They had assumed that that was the sort of average condition in which the iron was.

Prof. AYRTON said he quite agreed with what had been said about the value of the Paper and the amount of time and patience which must have been required to carry out these experiments. He must also agree with a good deal that had been said of a critical nature. He did not quite follow the first part of the Paper, where Mr. Vignoles proposed to give up lines of force from their quantitative sides and introduce the Thom—that was to say, he did not know what a Thom was. Mr. Vignoles said that the Thom did not suggest anything in particular, and he quite agreed with that; but possibly it might be as well to state what it was that he intended it to suggest. Mr. Vignoles said, "The Paris Congress has adopted a unit of induction density called the gauss." He presumed that that was true, but he was also sorry to say that at that moment he had quite forgotten exactly what a gauss was. He saw a certain advantage in this method of using, in the experiments on iron, what might be called the two magnetising coils method, the advantage arising when they wanted to pass from the negative magnetisation to the positive magnetisation. No doubt it would be possible with a single magnetising circuit to effect the same result, and reduce the current to the smaller value and reverse it at the same time; but it was very likely more easy to do it in the way that the authors had done, having ten amperes, or whatever it was, in circuit P_1, then to arrange such a resistance in the rheostat of P_2, that on starting the current P_2 the magnetising force was suddenly changed from its maximum negative value to the required positive value. Whenever that circuit was closed it would carry the magnetisation through its negative range, through O, to the required positive value; it might not be impossible, but it would be difficult to do that with a single circuit. He would suggest, too, that the secondary coil should have been wound close to the iron under the primary coils, as that would have got over the difficulty in the induction of the air space. With reference to Table 3A and the curves, he did not quite see why there should be a greater total induction—there might be a greater permeability.

Mr. VIGNOLES: No, is the induction density.

Prof. AYRTON: That showed the confusion that was caused by using words in a new sense—that was the same thing as permeability; it was not the total induction. He would not enter into what Mr. Vignoles called the "Mordey effect," except to suggest that he did not know whether it was wise to give these effects various names, because in a short time they would have all sorts of effects, A's effect, B's effect, &c., and it would be difficult to remember one effect from another. These effects merely stated what nature was, and why they were to be called by all sorts of different names he could not understand. If the particular effect in question was to be called any name, he would suggest that it should be called "the Central Institution effect," for the simple reason that in 1888 there were experiments made by students there, the results of which it seemed impossible to explain except by the diminished loss in the iron of a transformer as the load increased up to a certain point. For, in spite of the increased loss of power due to the heating of the primary and secondary coils as the load increased, the efficiency increased rapidly up to a very high value for a large load, and which seemed to indicate that the loss in the iron at this point was less than Prof. Ewing's results would lead one to expect. Prof. Ewing quite agreed with those experiments made at the Central Institution being possibly correct, since the iron in a transformer, and the iron he experimented with, were under very different conditions, and he thought that the experiments which Mr. Vignoles had made in his Paper threw absolutely no light on the matter. It was possible that in order to obtain exactly the conditions, they must have two large magnetising currents in opposite directions, slightly different in phase. He did not say that because there were those peculiar conditions that that was the explanation of the effect, but he did say that if any experiments were made, short of having two large magnetising currents in opposite directions differing in phase, and those experiments showed that there was no going down of waste on account of hysteresis as the load increased, the matter was open to doubt. It seemed to him that only with the transformer itself, or what was equivalent to the transformer, could they hope to get conclusive results. What they wanted was two large currents, roughly speaking, in opposite directions, but differing in phase. There was one other point in connection with this subject, and that was the experiments he had described at the Physical Society. He was speaking of the more recent experiments. The original experiments were made by means of the calorimetric method, but the more recent were carried out with Mr. Blakesley's dynamometer method. The proofs of the accuracy of Mr. Blakesley's method of measuring the power given to the primary of a transformer, as far as they had been given up to that time, assumed that there was no magnetic leakage. Prof. Perry had told him, in conversation, that he had proved that the split dynamometer method, even with leakage in the transformer, gave quite correct results. If that was the case, he was not aware of any error in the experiments that were described at the meeting of the Physical Society this spring. That would be an additional proof that there was a diminution of waste in the iron of a transformer, with increasing load up to a certain point. He had again to congratulate Mr. Vignoles and Mr. Evershed for the valuable contribution they had made to our knowledge of magnetism.

Mr. RUDDOCK thought that the gauss was more necessary than the thom. With reference to the curve shifting along the axis, as described on page 4, he did not see how the suggestion could hold in this case, because the iron was not magnetised at all between the two experiments, but simply had its scale taken off.

The PRESIDENT (Mr. W. B. Esson) said Prof. Ayrton had suggested that there should be definitions of the thom and the gauss, but he would suggest that the two terms ought to be struck out altogether, for he did not see the use of them. There was nothing indefinite about lines of force that he could see, and everyone knew very well what a line of force was, and that lines of force represented not only direction, but also quantity. There was one very practical point in the Paper having reference to the effect of removing the scale from soft iron plates. The results obtained by Mr. Vignoles and Mr. Evershed were the same that had been obtained by himself in a somewhat different way. He did not make a research, but he made up two dynamo armatures, in one of which the plates came direct from the annealing furnace, while in the other they were pickled, there being no difference in the result, which he supposed corresponded with what Mr. Vignoles and Mr. Evershed found. He would like to ask whether Mr. Vignoles had made any experiments with an alloy of iron and aluminium. He had two dynamo fields made, one having magnets of ordinary cast iron, and the other being a mixture of iron and aluminium, known as mitis metal, but when they came to test them, they found the alloy only gave about 5 per cent. more than the other; that was to say, with the same magnetising force, the induction at any part of the curve was only 5 per cent. more, so that he was afraid the advantage he got scarcely paid for the amount of aluminium put in. He would like to know whether Mr. Vignoles had made any experiments of that kind, for he must confess that he was rather disappointed with his results. Calculating the resistance of the magnetic circuit in both cases, and taking the permeability of the alloy as given by Prof. Thompson, they certainly ought to have been much better than he found them.

Mr. EVERSHED said, with regard to the objections that had been expressed to the use of the thom, it was not intended that every one should adopt it, but they could use it or not as they pleased. When he and Mr. Vignoles began the experiments, they thought they would like to understand each other, and that it was very desirable to use words of one syllable rather than more lengthened phrases, so they had thought it desirable to use the word "thom" in the sense in which it had been used. He had still another objection to the use of the term "line"; it might be feebleness of intellect, but when they came to talk about the earth's field being ·18 of a line he could not think of that, though when it was called ·18 of a thom, he could understand it. The method

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they had used for obtaining the scale of their ballistic galvanometer did not involve a logarithmic decrement—that was to say, all that they had done was to leave out of account altogether the logarithmic decrement. They found that it was easier to assume that the galvanometer had no law at all. They then got what was absolutely a straight line, every one point on the curve being the mean of some half-dozen observations. The method of correcting to infinity was only a convenient one—they might correct to any resistance they liked, but infinity seemed to be more convenient. With regard to Prof. Thompson's observations on the question of damping, the coil which was used certainly had a current maintained in it. He pressed the key and kept the key down, and, as they knew, if there was no damping whatever the maximum throw of the galvanometer was twice what the steady deflection would be. They always got the same deflection, so that they could always ascertain what percentage that deflection was reduced by if the galvanometer circuit was closed through any particular resistance. They did not have to think about the damping produced by that circuit, because it consisted of one wire tacked down on the table on which the galvanometer stood. A great deal had been said about Prof. Ewing's method. They had not criticised it in any carping spirit. They were engaged on different work, and wanted to find out what iron did in a transformer, so they wanted to make it jump from one definite point to another at the other end of the curve without waiting between. Unless Prof. Ewing had a magnetometer which would enable him to take the reading instantly, he did not see how he could do it so quickly as they had done; as a matter of fact, they had taken curves with the ballistic galvanometer by taking small deflections one after another, and then found the sum of all the deflections was 10 per cent. under the deflection which they would get if it jumped from the bottom up to the top suddenly. One of those curious results, namely, the shifting of the curve in a ring of iron showed that apparently there was an induction—he did not know whether they called it an induction or production—but there was something which he called induction in that ring, and something which they could not get out except by reversing the magnetising forces. If they subjected one of those rings which had its cycle shifted to one side of the axis of induction to half-a-dozen strong reverse cycles of magnetising force, the chances are that the curve they took afterwards would be symmetrically disposed about the axis. There was no doubt that if they took the theory of the damping, in which the logarithmic decrement came in, and worked it out, in a case where the needle of the galvanometer only moved through a very small angle they could easily see that the total induction coming from the needle never got outside the coils. When the needle moved through a large angle the laws of its motion became so complicated that they were obliged to use logarithmic decrement, but when it only moved six or seven degrees there was no necessity to do so. The theory indicated that it was a rectangular hyperbola. Of course, they might really assume that it was a rectangular hyperbola, but they preferred to make the experiments, and to be perfectly sure that they were right.

Mr. VIGNOLES said he hoped the results described might be of use to somebody. Dr. Sumpner and several other gentlemen had made remarks about thoms and gausses. It was quite easy to understand that they preferred to talk about a thom, instead of talking about the "line of force." Thom was short, and did not commit them to anything. A gauss, of course, was one thom per square centimetre; they were only convenient names. As to what Prof. Thompson had said about induction, of course he had not gone into the history of electricity to the same extent as Prof. Thompson, and he was not aware that Faraday was the man who first used "induction" for "magnetisation," but they had found the word induction being used in the sense of magnetisation, and they found it a very good one, and therefore they used the word induction in the Paper. In their own case, the only thing they wanted to do in talking of induction and induction density, was to distinguish between the total amount of induction and induction density. He had not used the words in a new sense. Some people talked of induction when they meant induction density; but he and Mr. Evershed had confined it to the total induction. Dr. Sumpner had made some remark about the shifting of the curve along its axis.

Dr. SUMPNER said it was not a critical remark at all, but he alluded to its being so very strange that he would like to hear more about it.

Mr. VIGNOLES said he could not tell any more than he knew, which was this, that when they plotted the curve, they found that, instead of being as it should be, there was displacement along the H axis. He did not know why it was. It might be due to previous magnetisation of the iron bars, but they had never been able to produce it when they tried. Prof. Thompson had made some remarks about Dr. Hopkinson's method. When they had a joint there it must affect the distribution of the magnetising force, and, therefore, that distribution could not be calculated unless they allowed for the magnetising force which was used in those joints. As to the broomstick being 40 times its length, the two things were perfectly different, but that did not matter.

Prof. THOMPSON: Then why does it matter in Dr. Hopkinson's case?

Mr. EVERSHED said he thought that the real reason was that in the case of the broomstick they could calculate how much error was introduced. In Dr. Hopkinson's method it was the same thing really, only they could not calculate it.

Prof. THOMPSON: Yes, that is quite right, only there is so little to calculate for, because of the enormous section of the iron.

Mr. VIGNOLES: With regard to the displacement which had been referred to, that might have been caused between two observations by putting both coils in the same direction, as Mr. Evershed had suggested. If they happened to put on the wrong coil first they might get an error in that way. It only remained for him to thank them for the very kind way in which they had received the Paper.

LEGAL INTELLIGENCE.

Mangan v. Metropolitan Electric Supply Company.

This action, which was heard on Wednesday, before Lords Justices Lindley, Bowen, and Fry, is brought in the Chancery Division, claiming an injunction to restrain the continuance of an alleged nuisance arising from noise produced by the working of electric machinery in Manchester-street, Manchester-square. The plaintiff also claims damages. The plaintiff applied for and obtained an interlocutory injunction to a limited extent, but a second application for an injunction was refused. The plaintiff afterwards applied, by summons in Chambers, for an order that the action should be transferred to the Queen's Bench Division, and be tried with a special jury. On this summons, Mr. Justice North made an order for transfer, and he refused a subsequent motion by the defendants to rescind the order. The defendants appealed.

Mr. Napier Higgins, Q.C., and Mr. J. G. Butcher were for the appellants.

The Court suggested that the best course would be to refer the action to an official referee for trial.

The defendants' counsel were willing to consent to this course, but Mr. Cozens-Hardy, Q.C., who (with Mr. Percy Gye) appeared for the plaintiff, declined to consent.

The Court dismissed the appeal, but reserved the question of the costs until after the trial.

LORD JUSTICE LINDLEY said that in substance the Court was asked to order Mr. Justice North to try the action himself after he had come to the conclusion that it would be better tried with a jury. The action was an ordinary one for a nuisance, brought in the Chancery Division. By means of the two motions for an injunction the learned judge had acquired a knowledge of the case. The plaintiff originally selected the Chancery Division, but he afterwards thought a jury would be a better tribunal for the trial than a judge alone. Mr. Justice North transferred the action to the Queen's Bench Division in order that it might be tried with a jury. This Court was asked to set aside the order on the ground that the learned judge, in exercising his discretion, had attached undue weight to the difficulty of assessing the damages. The appeal would be dismissed, but the costs would be reserved until after the trial.

LORD JUSTICE BOWEN and LORD JUSTICE FRY concurred.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *May* 16, 1891.

Gearless Motors.—Just now the most active part of electrical industry seems to be the street railway business. The two gearless motors that have already appeared have met with such success in experimental use that large numbers of each kind have been ordered, and a month or two will probably see a considerable number in use. The great question that remains to be settled is the durability of these machines. They are likely to have an electrical efficiency somewhat lower than that found in the ordinary geared motors, and the question naturally arises what would be the result of this when the machine is put to a very severe test in climbing heavy grades under adverse conditions—will the motor stand it? On the whole there is every reason to think, from the experiments tried so far, that it will stand it, although a few months of experience may teach some special precautions that will have to be observed to secure durability. Another point in question seems to be the effect of severe vibration on the windings of the armature. Some electricians seem to fear that this would produce frequent short circuits. The Short Electric Railway Company in bringing out its gearless machine endeavoured to dodge any possible trouble from this source by very careful cushioning. The Westinghouse Company, on the contrary, boldly put the armature directly and rigidly upon the axle, depending on solidity of construction and firm winding to shield the coils from harm. Both motors have stood experimentally very severe tests, and their respective performances will shortly furnish an interesting subject for study.

The Westinghouse Company.—The Westinghouse Electric Company has apparently emerged successfully from its financial difficulties, and is taking a very active part in the electrical operations of the present season. In spite of all sorts of rumours started by its rivals, Mr. Westinghouse succeeded in reorganising and putting the Company on a firm basis. The details of the arrangements that have been made will become public in a few days, but it is sufficient to say that some of the most prominent capitalists in New York City are now among

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the backers of the Company. In the letter last winter, when the difficulties were first announced, I expressed the opinion that such would be the outcome, and that confidence has been amply justified by the events of the past few weeks.

CORRESPONDENCE.

WESTMINSTER ELECTRIC SUPPLY CORPORATION (LIMITED).

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have just seen in your paper of last week Sir Wm. Thomson's Report on the electric lighting of Glasgow. I must ask you to allow me to correct a mistake which Sir William has there made. The system of feeders and network which I have laid down in connection with the work of the Westminster Corporation is neither identical with, nor even similar to, that described in Edison's English patent. If Sir Wm. Thomson had inquired into the details of the method I have adopted before he wrote his report, I feel sure that he would not have made the statement which I ask you to allow me to contradict.—Yours, &c., ALEX. B. W. KENNEDY.

19, Little Queen-street, S.W., May 25, 1891.

ELECTRIC LIGHTING AT GLASGOW.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I wish to call your attention to the fact that there is an arithmetical blunder in Mr. Crompton's calculations on the above subject. In his estimated cost of production of electricity he gives the cost of 400,000 units generated at Partick as £6,809. 1s. This is made up of—Cost, exclusive of engine-room expenses, £4,702. 13s.; engine-room expenses (B), £1,106. 8s.; total, £5,809. 1s.—*i.e.*, £1,000 less. This brings out the cost per unit as 3·5d., instead of 4·1d. According to these corrected figures, the advantages of his sixth scheme are not so apparent as he makes out by his figures.—Yours, &c., FRANCIS G. BAILY.

Maryon Park-road, Charlton, Kent.

ELECTRO-MAGNETIC INDUCTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I regret to again have to trespass on your space, but your remarks on my letter of last week seem to call for some brief reply.

You will, I am sure, see that the question of leakage is one which concerns transformers *in particular* and not in *general*. The action of the iron in transformers in general is the subject of our research; consequently, we cannot deal with leakage at the present stage.

As I have stated in my Paper, the chief point of our method is this,—that we try to imitate as closely as possible the action of the current in a transformer; and I submit that any impartial critic will acknowledge that our method must bring us nearer the conditions of the cycle, and therefore nearer the true **B H** curve of the transformer, than any method hitherto published. The only limits to the rapidity with which the induction change can be measured after a change in the current are the self-induction of the primary circuit and the period of the galvanometer.

The curves given in my Paper show plainly, to all who will study them, the vast importance of this instantaneous measurement, and the errors that may be produced by stopping at points on the curves other than the ends; and they therefore supply the strongest evidence in support of the method which we deduced from *a priori* reasoning.

As for our misuse of the word induction, "What's in a name," so long as we make ourselves understood? We do not want anyone to follow us in our nomenclature; I merely introduced it in my Paper because I am used to it; and to say, for instance, "change of magnetisation," where I mean "change of B," seems unnatural to me. We have always said "change of induction," and I do not think we are alone in using "induction" in that sense.—Yours, &c.,

ERNEST B. VIGNOLES.

Woodfield Works, Harrow-road, W., May 26, 1891.

TWISTED TELEPHONE LINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: To deal with all the inaccurate deductions of Mr. Bennett's last letter would occupy too much of your valuable space, so I will only draw attention to his admission that "noise can be found on 10 mile loops if specially listened for," which is hardly in accordance with the object and contention of his first letter.

I cannot but remark that Mr. Bennett appears to rely somewhat too much on the relation of his unfortunate experiences with twisted lines, "beyond his control," to support him in this discussion. I think it is at least premature to condemn a system, which has and is doing good work, upon such indefinite grounds.—Yours, &c., J. W. ULLETT.

TRADE NOTES AND NOTICES.

Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.]

In the course of a few days "The Electrician" Company will publish "THE ELECTRICIAN" PRIMERS in two volumes, price per volume 2s. paper covers, 2s. 6d. cloth.

TENDERS WANTED.—As will be seen by our advertisement columns, the Cleckheaton Local Board are prepared to receive tenders for lighting the Town Hall with electricity. Specifications may be seen at the Local Board offices, and tenders are to be sent to Mr. J. Armitage, the clerk, before Tuesday, June 9th.

MESSRS. CUTTRISS, WALLIS AND COMPANY (LIMITED).—We are in receipt of the new catalogue published by this firm, which contains particulars and prices of a number of their manufactures, including the "Eclipse" and "Improved Ring" dynamos, the "Alliance" and "Volt" dynamos and motors, a dynamo specially constructed for students, a dental dynamo, a small motor and fan, batteries, Cuttriss' calculating discs, &c. Included in the catalogue are several flattering testimonials from users of Messrs. Cuttriss, Wallis and Company's machines.

THE WHITEHALL DYNAMO AND MOTOR.—Messrs. Easton and Anderson have issued a circular describing their dynamos (Prentice's patent). Eight sizes are made, all parts of the same size being interchangeable. It is probable that if dynamo building were more widely taken up by such well-established firms we should see less of the clumsy and amateur-looking machines which are offered to the public by "electrical engineers and manufacturers."

ELECTRIC CRANES.—Messrs. R. Bolton and Co. have issued an illustrated list of electric travellers, winches, cranes, and derricks. The feature of these cranes is a triple gear, consisting of two winding barrels of different diameters. To these the two ends of the lifting rope are attached. The barrels may be separately or simultaneously clutched to the motor, thus allowing three different speeds to be obtained while the motor runs at a constant speed in one direction. The loads are given against the different sizes, but the speed of lifting is not stated.

ELECTRIC LIGHT PILLARS.—Messrs. W. Macfarlane and Co. have sent us their illustrated price list of lamp posts and ornamental brackets for street lighting, together with other very decorative pillars of a smaller size for use in large buildings, &c.

MESSRS. W. H. WILLCOX AND COMPANY.—This firm notify us that they have extended their premises by taking the warehouse adjoining No. 36, Southwark-street, which will give them greater facilities for dispatching orders received, and will enable them to hold a much heavier and more assorted stock of lubricating and cylinder oils, engineers' tools, and general stores.

MESSRS. ANDERSON, CAMPBELL, AND MUNRO (LIMITED), (IN LIQUIDATION).—A meeting will be held at Mr. David Strathie's, 162, St. Vincent-street, Glasgow, on June 22nd, at 12, for the account of the winding-up.

BUSINESS AMALGAMATION.—We are informed that Bernstein's Electricitätswerke Kommandit-Gesellschaft, of Hamburg, have amalgamated with the Allgemeine Electricitäts Gesellschaft, of Berlin, and that a new company will be formed in the latter city.

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COMPANIES' MEETINGS & REPORTS.

The Consolidated Telephone Construction and Maintenance Company (Limited).

The tenth annual ordinary general meeting of the Consolidated Telephone Construction and Maintenance Company (Limited) was held at the Terminus Hotel, Cannon-street, yesterday, Mr. C. L. W. FitzGerald presiding.

The SECRETARY read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen, as you will observe from the report that we have presented to you, you will see that the profit for the year amounted to the sum of £11,573. 8s. 9d., which, with the amount brought forward from last year, leaves a balance to dispose of amounting to £13,416. 6s. 8d. The Board propose that we should pay a further dividend of 7 per cent. for the half-year on the ordinary shares, and 6 per cent. on the preference shares. This will make a dividend for the entire year of 6 per cent. for both descriptions of shares, £530. 3s. being written off for depreciation of plant and machinery, £63. 16s. 8d. for the cost of the new building, and the sum of £436 for goodwill, patent rights, &c. Now, gentlemen, in turning to the other figures, the first item that I will call your attention to is one that, of course, we look very much after, and that is the profit on manufacturing. The profit this year from that source is less by £253 than it was last year. I think, however, that if we consider everything that is not a bad result. Wages have increased, as also has the price of coal. In fact, the cost of all the materials pretty well that we use have increased, and yet we have come out with a loss of only £253. On the other hand, you will see that we received more in dividend from some of our subsidiary companies, and interest to the extent of £534, and this despite the fact that we have received only £50 from the River Plate investment, as against £250. On the debit side we find that our expenses have risen a little. The auditors' remuneration, if you recollect, we increased last year, and the travelling expenses have advanced slightly. The total increase on the four items under the head of general management, &c., comes to £135, and when I come to add up the entire outlay for the year I find that we have expended only £40 more than we did during the previous twelve months. I think that this may be considered very satisfactory. Coming to the balance-sheet, you will see that our plant and machinery are now valued at, I think, £520 less than they were last year, and this, I should tell you, notwithstanding that we have added very considerably to the plant by getting some very fine new machinery. I think I can safely say that the Company's plant was never more efficient than it is at the present moment. I am now engaged with the officials of the Company in reorganising the entire plant, in order to enable us to turn out more goods, as I found that, since December 9th last, which you will see by the report was the date at which one of the patents held by the National Telephone Company expired, there was an increase of business, and, therefore, we had to do something at the factory to enable us to keep pace with the demand upon us. You will see a little lower down that our stock comes to the sum of £6,895. 16s. That stock, I am happy to state, has decreased since last year. That means to say, of course, that we have not got so much stock on hand as we had last year. Of course, this was to a certain extent inevitable, because we have sold more of our manufactures which were completed instruments. Still lower down, you will see that the subsidiary and other companies owe us the sum total of £8,993. 3s. 5d.; while, on the other side of the balance-sheet, you will find that we owe only £1,669. 8s. 10d. I think that that is a very satisfactory feature of the report. I now come to the investments. As you are aware, this year we have not asked the shareholders to subscribe for any money in the form of preference shares. The two previous years we did. In the first of these we asked for £15,000, and in the second for £10,000. This year we have asked for nothing, but we have added to our investments. We have increased by no less a sum than £10,500 Anglo-Portuguese Telephone Company's debentures, and added £4,000 to the preference shares of the Telephone Company of Austria. Now, I should like to say a word—I was in hopes that Mr. Griffiths, our auditor, would be here to explain the matter, but he has not come—on the subject of two of your investments. The auditors have called the attention of the Board to the fact that some of the securities held by the Company have depreciated in value during the year. The Directors are of opinion that this depreciation may be only of a temporary nature; but should this view prove incorrect, it will, no doubt, be advisable to form a fund against this depreciation. Now, gentlemen, these two items refer to the National Telephone Company of London, and the River Plate Telephone Company of Buenos Ayres. I will take the latter first. The depreciation of this security is not owing to the business of that Company being bad, but to the fact that, by reason of the difficulties in which the Argentine Republic has been placed, and the enormous premium on gold, that Company cannot remit to this country the money it earns there in sufficient amount in order to pay us a dividend. The National Telephone Company, to my certain knowledge, is doing a bigger business than it ever did, and I know that it will pay us a good dividend; in fact, I know that it is going to give us a return almost directly. The lawsuit in Belgium seems to go on dragging its way along. It seems to me, indeed, that all law suits go on in that sort of way. Whether we are any nearer a decision I do not know, but we hope we are. I now come to the subsidiary companies, which I regard as a most gratifying item. These companies increase steadily year by year. This year the Telephone Company of Austria and the Anglo-Portuguese Telephone Company have increased in subscribers 564, representing an augmentation in the amount of revenue of £3,626. The previous year, I think, the increase was only about £50 more. I do not think I have anything more to say to you. I do not like prophesying, but I must say that I think the outlook of the Company is very good. Personally, I am very pleased with this balance-sheet, and all that I can say for myself and the Board is that, being very largely interested in the Company, we shall try to do our best to keep it in a satisfactory position, and to give you, if possible, increased dividends. I now beg to move,—

"That the annual statement of accounts and balance-sheet, and the report of the Directors as now submitted, be received and adopted."

Of course, if anybody would like to ask any questions, I shall be most happy to answer them to the best of my ability.

Sir ALEXANDER ARMSTRONG seconded the motion, which was carried unanimously without discussion.

On the motion of the CHAIRMAN, seconded by Mr. RICHARD VANZELLER, the retiring Directors, Sir Alexander Armstrong and Mr. Arthur Henry Baker, were unanimously re elected to their seats at the Board.

The auditors, Messrs. John G. Griffiths and Mr. Arthur Green were afterwards reappointed *nem. con.*

A SHAREHOLDER asked the Chairman whether he considered the patent rights of the subsidiary companies of any value?

The CHAIRMAN: Oh, certainly. We have never, from the commencement of the Company, taken them into our balance-sheet, but they are really increasing in value every day.

The SHAREHOLDER asked whether they were of marketable value?

The CHAIRMAN: I cannot say that.

The SHAREHOLDER: Could you get anything for them?

The CHAIRMAN: Oh, yes, we could. I should be very happy to give something for them.

Mr. BUCKINHAM said it would be remembered that in 1884 a committee of investigation was appointed by the shareholders. The result was that the then Directors felt it more or less their duty to vacate their seats, and others were appointed in their place. From that time to this the Company had gone on slowly but surely prospering. At all events, he for one, as an original shareholder of the Company, was very much more satisfied with its prospects than ever he was before. The Directors at that time, as well as the committee, very earnestly wished that he should join the Board, but unfortunately he was not able to do so. But three or four years ago they did him the honour to renew their request, and he consented to join them. When he did so, he found that there were certain actions on the part of the old Directors of the Company pending, all of which he was happy to say had been very satisfactorily settled. The last action was not commenced until four years after the committee had issued their report. In consequence of certain phrases which appeared in it, and which gave displeasure to one of the old Directors. It kept hanging over them until 1890, when he, who had always an aversion to law, which it was always advisable to avoid having recourse to if possible, advised his colleagues to compromise the matter. This they agreed to do, and the action was settled out of court. Knowing the amount of labour and trouble which the Directors had had to get over all those difficulties, and knowing the amount of influence which Mr. FitzGerald had brought to bear on the Company—and without that gentleman's efforts he was bound to say that he did not know how the Company could have existed up to the present time—he had very much pleasure in proposing the following resolution, which he was sure would meet with acceptance on the part of the shareholders:—

"That, having regard to the special services rendered to the Company by Mr. C. L. W. FitzGerald, Mr. Henry Grewing, and Mr. Arthur Henry Baker" (the three Directors against whom the action was brought) "as members of the Committee of Investigation, and the expenses consequently incurred by them, this meeting votes them a payment, by way of reimbursing them, of a sum not to exceed £600."

Mr. R. E. BATEMAN said that, although this was the first time he had heard of this proposal, he had the greatest pleasure in seconding the motion, and in recommending his fellow shareholders to give it their support. He would not use any expressions reflecting on the former members of the Board, but when the shareholders took into their consideration the way in which the three gentlemen named in the resolution had managed and improved the value of their property, he did not think they could do otherwise than approve the resolution.

Mr. S. C. BUCK supported the motion, remarking, that, but for Mr. FitzGerald and his other two colleagues, the shares of the Company would not now be worth sixpence.

The SOLICITOR, referring to the last of the actions brought against the Company, said that, as their legal adviser, he strongly felt in 1890, when their affairs were in a fair way to go on prospering, that it would be to their great disadvantage if the whole of the past history of the Company had to be raked up in a court of law, notwithstanding that the three gentlemen against whom the action was brought were perfectly prepared, having a clear conscience, and having at all times acted *bona fide* in the interests of the shareholders, to go into court; and, consequently, he brought pressure to bear upon them, in the interest of all parties, to terminate the matter by the compromise that had been happily arrived at.

The resolution was carried unanimously.

The CHAIRMAN briefly returned thanks on behalf of himself and colleagues, assuring the meeting that it would be their earnest endeavour in the future, as in the past, to do all they could to promote the prosperity of the Company.

Before separating, the shareholders were invited to inspect several specimens of the Company's manufactures, which were on view in the room.

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The Indo-European Telegraph Company (Limited).

An extraordinary general meeting of the members of this Company was held at the offices, Old Broad-street, last Monday, under the presidency of Mr. J. H. Tritton, when the following resolution, duly passed by the requisite majority at the ordinary general meeting of the Company, held on April 28th last, was submitted for confirmation as a special resolution :—

"*That in addition to the regulations of the Company, as contained in the Articles of Association, the following new regulation (to be numbered* 116a) *be adopted, that is to say—*

"*That the present Managing Director of the Company shall be a member of the Board, having all the privileges and being subject to all the obligations of an ordinary Director, except that he shall not receive extra remuneration as a Director, nor shall he retire from office by rotation. If the Directors think fit, this provision shall apply to any future Managing Director whom they may appoint.*

"*The other regulations of the Company shall be treated as qualified so as to give full effect to this new regulation.*"

The MANAGING DIRECTOR (Mr. W. Andrews) having read the notice convening the meeting, as above,

The CHAIRMAN said: Gentlemen, I declare the meeting to be duly constituted. It is a special meeting, called in accordance with the articles of association, in order that the resolution which has been read to you, and which was submitted to our ordinary general meeting, may be placed before you for consideration, and, if you think fit, for confirmation. Having read the resolution as above, he said: I have great pleasure in moving that the resolution be approved and confirmed.

Mr. WEAVER having formally seconded the motion,

The CHAIRMAN submitted it in the usual manner, and declared it carried.

The proceedings then terminated.

The City of London Electric Lighting (Pioneer) Company (Limited).

The first ordinary general meeting of this Company was held at Winchester House, Old Broad-street, E.C., on Monday, the 25th instant. The notice stated :—"This being merely the formal statutory meeting (in accordance with the requirements of the Companies' Act), there will be no business to be transacted. The Directors, however, take this opportunity of informing the shareholders that suitable sites have been secured for the central generating stations by the contractors, and that good progress has been made by them with the necessary buildings, machinery, and mains, and that it is hoped that the first portion of the public lighting in Queen Victoria-street will be completed by June 1st. In order to be prepared to meet any claims for work done and certified as satisfactory by their consulting engineer, the Board consider it advisable to call up the balance of the capital at an early date, due notice of which will be given."

The Lord Mayor presided.

Mr. J. CECIL BULL (the Secretary) read the notice calling the meeting as above.

The CHAIRMAN said: Gentlemen, you have heard by the notice which the secretary has read that this is merely a statutory meeting, which is obliged to be held within four months of the registration of the Company, in accordance with the requirements of the Joint Stock Companies Acts; but doubtless the shareholders will be anxious to learn what we have done during these four months. You will be glad to hear that, notwithstanding the great financial depression and difficulty at the time, we were enabled to launch this Company most satisfactorily. The capital was applied for nearly three times over, and we were enabled to arrange for the issue of the Company upon the most economical terms. There has been some misconception in the minds of many people as to the duties and the scope of the Pioneer Company, and I should like to point out that the object of the Pioneer Company, as stated in the prospectus, was not to take over the Provisional Orders and contracts, but to initiate the supply of electricity by providing the contractors with funds by enabling those contractors, after they had obtained the concessions from the Commissioners of Sewers, and the authority of the Board of Trade, to proceed with the work which they had undertaken, the right being reserved to launch at some future time a larger company to take over the concessions which had been secured. I should like to mention that in our early days we summoned some of the leading electricians to meet the Directors, and several meetings were held, and were very largely attended. The object of these meetings was to decide which were the best means and methods for lighting the City of London, and it was most satisfactory that the authorities upon electric lighting in this kingdom who were summoned were unanimously of the opinion that the system which the Board have since adopted was the best suited for our requirements, and this was why we decided to carry their recommendation into effect; and we feel certain that when the electric lighting of the City of London is completed we shall have a city lighted in a way which will be second to no other city in the world. It will be a matter of satisfaction to you to know that we have secured most suitable sites for placing our machinery. That for the eastern district of the City has been secured near Tower Hill, and for the central and western districts on Bankside. The Directors thought it advisable while the streets were being taken up to lay down the necessary conduits for the electric lighting, already agreed upon, to take the opportunity of laying down additional conduits in order that the streets may not be disturbed again, because that is, of course, always a matter of considerable annoyance whenever it is done. The Board of the Pioneer Company during the four months that it has been in existence has been doing a great deal of preparatory work in order to assist in every way possible the new company which is proposed to be started at no distant period, and we have been getting out statistics, with the help of our consulting engineer, and making numerous other preparations, such as deciding upon the routes for the conduits and mains, making various plans of the several districts of the City, schedules of prices, and so on, all of which will be of great use to the Board of the new company, and enable them to arrive at a satisfactory estimate with regard to the work which they will be called upon to undertake. I might also mention that the work of one firm of contractors is so far advanced that we hope that Queen Victoria-street will be lighted by electricity about the middle of next month. The larger Company (which will, as I mentioned in the earlier part of my remarks, be entitled to take over the contractors concessions, which have been obtained from the Commissioners of Sewers with the sanction of the Board of Trade) will, we hope, be arranged within a comparatively short period, and the formation of that Company is now in the hands of men of such very high standing and undoubted reputation, that I feel confident it will eventually return not only a fair remuneration to the shareholders, but also secure for the City of London the most perfect and unique system of electric lighting. We, for our part, have taken the greatest possible care in reference to every small detail; even the construction of the lamps and various other minor matters have received the most careful attention of the Board of Directors, and I can assure you, speaking not only as Chairman of this Company, but as Lord Mayor of the City of London, that I am entirely satisfied with the work that the contractors have done as yet. I have no resolution to put to the meeting, but I shall be happy to answer any questions that any of the shareholders desire to ask.

Mr. EDWARD LEE said that he wished to suggest that in the event of further capital being required, that capital should not be raised by calling up the present uncalled amount of the shares, as hinted in the notice calling the meeting, because he considered that their uncalled capital was their strength, and if further capital was required, he should suggest that it should be obtained by the issue of additional capital. He felt perfectly satisfied, after the remarks that they had listened to from the Lord Mayor, that all the shareholders would be willing to take up whatever new shares might be required. He was very much gratified at the statement of the Chairman and with the ability with which everything appeared to be conducted.

No further questions were asked.

The LORD MAYOR, in reply, said that if it should become necessary as far as the Pioneer Company was concerned to call up more capital it would only be required for a very short period, because the new company which was to be formed would purchase what the Pioneer Company had done, and therefore the shareholders in the Pioneer Company would be enabled either to take shares in the new company or to have their money returned, just as they pleased. The interest of the Directors of the Pioneer Company was the interest of the shareholders of that company, and the matter of the new company would be entirely one for the shareholders to consider for themselves, and for each one to do what he deemed best in his own interest.

Mr. LEE said that his only reason for raising the point was whether the amount of capital that the Company now possessed would be sufficient for carrying on the works until such time as a new company was formed.

The LORD MAYOR: We think so. We think it is ample. If any other gentleman has any question to ask I shall be happy to answer him. (A pause.) Unless any gentleman has any question to put, that really concludes our meeting to-day, because there is nothing—no business—before the shareholders, as this is only a statutory meeting which we are compelled to hold.

Mr. S. MACLEAY said before they separated he begged to propose a vote of thanks to the Right Hon. the Lord Mayor for presiding, and to the Board of Directors who appeared to have done all in their power to further the interest of the Company.

Mr. HEPBURN seconded the motion, which was carried.

The LORD MAYOR, in reply, said that, on behalf of his colleagues and himself, he must say that they appreciated very much indeed the vote of thanks which had been kindly accorded to them. Their one desire was to do their utmost to make the electric lighting of the City of London as perfect as it could possibly be, and he thought that they might feel satisfied that in the Pioneer Company, and he believed he might also say confidently in the larger company to be formed, the shareholders would find they had a very sound investment.

The proceedings then terminated.

Birmingham Electric Supply Company (Limited).

The first annual meeting of the shareholders of this Company was held on Tuesday, at their offices in Dale End, Birmingham; Mr. Henry Buckley in the chair.

The following is the report of the Directors :—"The Directors are glad to be able to announce that the works of the supply station and the mains through a considerable portion of your area are complete and in working order. The works were formally opened by the Mayor (Mr. Alderman Clayton) on April 22, 1891. The demand for the light has been most satisfactory, and the works start on a system of 2,580 16 c.p. lamps. These lights are distributed amongst various offices and shops representing some of the most important professional and trade interests in the city, one of the first customers being the Corporation of Birmingham, with whom arrangements are made for the lighting of the Victoria Courts. In the purchase of the land and the laying out of the works and mains it has been necessary to provide for not only the present but for the future demand for the light—*i.e.*, the available land is sufficient for a station estimated to

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provide 25,000 16 c.p. lamps, and a chimney stack has been built large enough for this. The engine-house and boiler-shed will be sufficient for half this number, and for the immediate supply engines and boilers have been fixed for 5,000 lamps. Mains have now been laid through the most important streets within the Company's area, and current may be obtained along 7,000 yards of street frontages. The Company have been fortunate in securing a substantial tenant for a portion of the offices which will not at present be required."

The CHAIRMAN, in moving the adoption of the report, said he had not a great deal to add to what he said at the recent opening of the Company's works. The orders were coming in very satisfactorily. Up to the present they had received orders for 2,639 lamps, but when they saw that such orders were spread over only 42 customers it showed the shareholders what a good opening there was for the extension of their trade in the city. Bearing this in mind, the Directors had resolved to issue the balance of the shares in the first instance amongst the shareholders. This would enable them to cope with additions to plant that the extension of business will demand, and he was glad to inform them that, considering the broken holiday week, the shares had been well taken up. The Chairman went on speaking of the question of dividend. He thought he was justified in the statement that with the present year they would be able to pay the entire working expenses, and, if that turned out as he expected, at the end of 1892 there was reasonable expectation for them to pay a dividend. But that must depend upon the earning power of the Company in Birmingham and the number of lamps applied for, and, judging by the experience of other electric companies, he believed they would be making a profit from 1892.

The report was adopted.

Mr. G. S. Albright and Mr. Buckley, the retiring Directors, having been re-elected, and the auditors (Messrs. Sharp, Parsons and Co.) having been reappointed, the meeting separated.

Notting Hill Electric Lighting Company (Limited).

The following is the Directors' report, to be presented at the fourth ordinary general meeting, to be held at the Central Electric Light Station, Bulmer-place, Notting Hill-gate, London, W., on Saturday, May 30th, at 4 p.m.:—

The Directors beg to submit herewith the accounts of the Company to December 31, 1890. It will be observed that the expenditure on capital account covers a period of nearly three years, from February 21, 1888 (the date of incorporation of the Company), to December 31, 1890. As, however, before the publication of the prospectus in January, 1890, no shares were issued beyond a few originally subscribed for and paid up in full by the founders of the Company, the bulk of the expenditure on the works has been incurred during a period of less than twelve months. On December 31, 1890, the capital paid up was £42,676, and the liability on the shares issued amounted to £27,444, and there remained £29,980 of unissued capital. Altogether 7,002 shares have been subscribed, and a special settlement was obtained on the Stock Exchange on July 1, 1890, for the 6,318 ordinary shares of £10 each, which were applied for and allotted in accordance with the prospectus, and an application has been lodged with the Stock Exchange Committee for a quotation of these shares upon the official list. The capital expenditure, as shown by the accounts, amounted at the end of the year to £43,126. 5s. 2d., but this sum does not include the further liabilities on contracts entered into for construction of buildings, mains, and machinery, since nearly completed. These amount to about £12,000, bringing the total expenditure incurred and contracted for before the date of the opening of the works to about £55,500.

Subsequent to the purchase of the lease of the property for a central station in Victoria Gardens, Notting Hill, which is referred to in the prospectus, the Directors took the opportunity which offered itself of acquiring the freehold. It also became necessary, owing to injunctions which were obtained during the construction of the central station by the owners of neighbouring property, to purchase the lease of seven small houses adjoining in Bulmer Place. These houses are all let.

Considerable delay occurred in the completion of the works, owing, in the first place, to the injunctions above mentioned, and when the work could have been resumed the very severe weather supervened, thus making it impossible for the contractors to proceed for a considerable time with the building of the central station. The Directors are, however, glad to state that the central station has been now completed, and the Company is able to supply the electric current to houses situated in the principal streets of the northern and central portion of the area of supply, in which the mains have already been fixed.

The number of houses in the district which are prepared to take the light is continually increasing. Already the owners of 70 houses have notified their readiness to take the lght. This number includes Holland House, and it is estimated that at the present time the installations comprise a total number of about 4,000 lamps, reduced as usual to 8 c.p. The engineers have reason to believe that a considerable number of householders are intending to have their houses wired as soon as the current is actually being delivered, and it is expected that before next winter the generation of the amount of electrical current supplied to customers will profitably occupy the whole of the existing plant.

Much difficulty has been experienced in obtaining a site for a second central station, but a provisional contract has now been entered into in reference to a site which the Directors consider well suited for the purpose, and, as soon as the agreement is completed, steps will be taken to lay the mains in the southern part of the district, when the whole of the parliamentary area granted to the Company can be supplied with the electric current. In this southern district an increase in the number of customers is to be expected, in consequence of the decision of Lord Ilchester to let for building purposes about 2½ acres of Holland Park.

The Directors who retire are Messrs. A. Howden and J. T. Jarvis, who, being eligible, offer themselves for re-election. The auditors, Messrs. Deloitte, Dever Griffiths & Co., retire, and being eligible, offer themselves for re-election.

NEW COMPANIES REGISTERED.

ARC ACCUMULATOR COMPANY (LIMITED).—Registered by Sydney Morse, 4, Fenchurch-avenue, E.C., with a capital of £1,000, in £1 shares. Object: To carry on in the United Kingdom the business of electricians, electrical engineers, &c.

CLEGG'S METAL INCANDESCENT LAMP COMPANY OF FRANCE (LIMITED).—Registered by Bircham and Co., 46, Parliament-street, S.W., with a capital of £10,000, in £10 shares. Object: to carry into effect an agreement, made May 13, between James Clegg of the first part, Betts and Co., Limited, of the second part, and this Company of the third part, for the acquisition of certain inventions and patents relating to electric lamps and other electrical appliances, and to develop and work the same. There shall not be less than three nor more than eight Directors. The first are Archibald Campbell, Charles Cheswright, sen., James Clegg, Allan Maclean, Charles Cheswright, jun., Leveson Dudley Ryder, and Henry Tyler Cheswright. Qualification not specified. Remuneration: Ordinary Directors, £350, divisible; Managing Director's remuneration to be determined in general meeting.

FOREIGN AND COLONIAL ARC ACCUMULATOR COMPANY (LIMITED). Registered by Sydney Morse, 4, Fenchurch-avenue, E.C., with a capital of £1,000, in £1 shares. Object: to carry on elsewhere than in the United Kingdom the business of electrical engineers, &c.

WOODFIELD SYNDICATE (LIMITED).—Registered by Maynard Carter, with a capital of £12,000, in £1 shares. Object: to carry on the business of an electrical engineer in all its branches in Great Britain or any other part of the world. There shall not be less than two nor more than five Directors; the first are to be appointed by the subscribers to the memorandum of association. Qualification, being a shareholder. Remuneration to be determined in general meeting.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the past week amounted to £4,730.

CITY AND SOUTH LONDON RAILWAY COMPANY.—The traffic receipts of this Company for the past week amounted to £768.

COMPAGNIE FRANCAISE DU TELEGRAPHE DE PARIS A NEW YORK. At a meeting of this Company held at Paris, it was decided that an emission should be made of sufficient bonds to raise the capital to 12,000,000f.

COMMERCIAL CABLE COMPANY.—The Stock Exchange Committee have ordered the further issue of $500,000 stock to be quoted in the Official List.

INDIA-RUBBER ESTATES COMPANY.—Under a winding-up order, made against this Company on the 11th ult., a summary of the statement of affairs has now been issued by Mr. Stewart, the Official Receiver. The liabilities amount to £3,662, and an estimated surplus of £2,033 is disclosed. The Company was registered on July 2, 1890, and was formed for the purpose of acquiring and working a concession from the Government of the Republic of Liberia for the sole right of collecting and exporting india-rubber and gutta-percha from the said Republic for the European and American markets. The nominal capital of the Company is £225,000, in £1 shares, of which 132,024 have been allotted. There are 120 shareholders. The purchase-money originally agreed upon was £155,000, but appears to have been subsequently reduced to £144,000, of which a balance of £20,000 is unsatisfied. The insolvency of the Company is attributed generally to the inability of the Directors to obtain from certain shareholders a sufficient portion of the unpaid calls to complete the purchase of the concession, which has never come into the Company's possession. Mr. Stewart observes that the whole circumstances connected with the payment of the purchase-money would appear to require further investigation. As regards contributories a deficiency of £129,990 is disclosed. It is stated that a scheme of reconstruction is likely to be proposed.

RICHARD HORNSBY AND SONS (LIMITED).—The Directors have declared a dividend for the past half-year of 3s. 3d. per share.

RUSTON, PROCTOR, AND COMPANY (LIMITED).—The second annual general meeting was held at the Cannon street Hotel, on Tuesday, under the presidency of Mr. Joseph Ruston, when a dividend was declared of 10s. per share, free of income-tax, making, with the interim dividend of 5s. per share paid on November 1st last, a total dividend of 7½ per cent. for the year.

SPANISH NATIONAL SUBMARINE TELEGRAPH COMPANY (LIMITED).—The numbers are announced of 81 Six per Cent. Mortgage Debentures, amounting to £8,100, to be paid off at par on or after June 30th next.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended May 22, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,803.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The receipts of this Company for the two weeks ended May 15th amounted to £3,116, as compared with £3,270 for the corresponding period last year, showing a decrease of £154.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, May 20.	Price Wednesday, May 27.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending May 27. Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
£1,381,380	Stock	12/0	Anglo-American	46½ 47½	46½ 47½	6 0 0	Jan., Apr., July, Oct	.. ..	.. ..
£2,809,310	Stock	21/0	Do. Preferred	84 85	84½ 85½	6 14 6	" "	86⅛	84½
£2,809,310	Stock	..	Do. Deferred	11½ 12	11½ 12	..		12	..
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99 102	99 102	3 18 5	January and July ..	100	..
180,000	£10	3/0	Brazilian Submarine	11⅞ 12½	11⅞ 12½	6 2 5	Mar., June, Oct., Dec.	12½	11⅞
£284,500	£100	5%	Do. 5 per Cent. Bonds	101 104	101 104	4 16 2	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	104 108	104 108	4 12 7	June and December	104½	..
$7,216,000	$100	7%	Commercial Cable Capital Stock	108 110	106 108	6 0 4	April and October ..	106	..
16,000	10	8/0	Cuba Submarine	10½ 11½	10½ 11½	6 19 2	February and August	11	..
6,000	10	10%	Do. Preference 10%	16½ 17½	16½ 17½	5 14 3	" "	..	..
12,981	5	3/2½	Direct Spanish (£4 paid)	3½ 4½	3½ 4½	6 11 9	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	10½ 10½	10½ 10½	6 13 4	Jan., Apr., July, Oct	10⅞	10½
400,000	10	2/6	Eastern	14⅜ 14⅝	14⅜ 14⅝	4 8 10	" "	14⅝	14⅜
70,000	10	6%	Do. 6 per Cent. Preference	15½ 15⅝	15½ 15⅝	3 16 2	" "	15⅝	15½
£1,200,000	Stock	6%	Do. 4 per Cent. Mort. Debenture Stock	106 109	106 109	3 13 5	May and November	108⅛	108⅜
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	107 110	4 10 11	February & August	108⅛	107
250,000	10	6/6	Eastern Extension	14⅜ 15½	14⅜ 15	4 13 4	Jan., Apr., July, Oct.	15	14⅜
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock	105 108	105 108	3 14 1	..	107	..
£91,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103 106	103 106	4 14 4	January and July ..	..	..
£145,800	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	103 106	103 106	4 14 4	" "	104⅛	103
180,227	10	2/6	Globe Telegraph and Trust	9½ 9⅝	9½ 9⅝	5 7 10	Jan., Apr., July, Oct.	9⅝	9⅜
180,042	10	6%	Do. 6 per Cent. Preference	14⅜ 15⅛	15 15½	3 18 8	" "	15⅛	14⅜
150,000	10	7/2	Great Northern	17⅛ 18⅛	18 18⅛	4 11 11	Jan., April, and July	18⅛	18
£15,000	100	5%	Do. 5 per Cent. Debentures, 1881	.. ..	.. ..	..	January and July ..	..	..
£180,000	100	5%	Do. 5 per Cent. Debentures, 1883	105 108	105 108	4 12 7	March & September	..	..
17,000	25	12/6	Indo-European	39 41	39 41	4 11 6	May and November	41½	..
32,848	10	4/0	London Platino-Brazilian	6½ 7⅛	6½ 7⅛	6 0 0	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106 109	106 109	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's	8 8⅛	8 8⅛	4 14 1	April and October..	8⅛	..
3,381	£100 Cert.	6%	Submarine Cables Trust 6%	116 121	115 120	5 0 0	" "	1 6	..
15,609	10	4/0	West African Telegraph	8 9	8 9	5 11 1	January and July ..	..	..
£230,900	100	5%	Do. 5 per Cent. Debentures	96 99	96 99	5 1 0	March & September	98	..
30,000	10	3/0	West Coast of America	3⅞ 4⅛	3⅞ 4⅛	..	January and July ..	..	..
£150,000	100	8%	Do. Debentures 8% 1902	100 105	100 105	7 12 5	June and December	..	..
88,321	10	9d.	West India and Panama	3 3½	2⅝ 3⅛	..	..	3⅛	2⅛
34,563	10	6/0	Do. 1st Preference 6%	11⅜ 12⅜	11⅜ 12⅜	4 18 0	May and November	12⅞	12
4,669	10	£3	Do. 6 p. c. 2nd Pref.	11⅛ 12⅛	11⅛ 12⅛	4 16 0	" "	11⅝	..
64,174	15	6/0	Western and Brazilian	11 11⅛	11 11⅛	6 10 7	" "	11⅛	11⅛
27,878	7½	6/0	Do. 5 per Cent. Cumulative Preferred	6⅛ 7	6⅛ 7	5 7 3	—	..	..
27,878	7½	4/6	Do. 5 per Cent. Deferred	4⅜ 5⅛	4⅜ 5⅛	..	..	..	..
£210,000	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103 106	103 106	5 13 2	February & August	..	..
£250,000	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103 106	103 106	5 13 2	" "	105½	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	117 122	5 14 9	May and November	117	..
£175,100	£100	6%	Do, 6 per Cent. Sterling Bond	100 104	100 104	5 15 5	March & September	..	..
			TELEPHONES.						
224,850	14/0	0/4½	Consolidated Telephone Const. & Maintenance.	⅛ ¼	⅛ ¼	6 14 5	May and November	⅛	..
220,000	£1	4/76	Oriental (11s. paid)	⅛ ¼	⅛ ¼	5 2 11	Yearly	..	..
438,984	5	2/6	National	4⅛ 4½	4⅛ 4½	5 12 10	June and December	4⅛	4⅛
15,000	10	6/0	Do. 6 per Cent. Cumulative 1st Pref.	12½ 13½	12½ 13	..	" "	..	..
15,000	10	4/9⅜	Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd)	12 12½	12 12½	3 16 10	" "	12⅛	..
..	£100	..	Do. Debenture Stk. 4½% Prov. Cert. (fully pd)	102 104	103 105	4 5 9	..	..	..
209,750	1	..	South of England, Ordinary	.. ..	.. ..	..	—	..	..
20,000	5	..	Do. 6 per Cent. Cumulative Pf. (£3 10s. pd)	.. ..	.. ..	..	—	..	..
58,000	5	1/0	United River Plate	2½ 3½	2½ 3½	..	January and July ..	..	..
£146,128	Stock	5%	Do. 5 per Cent. Debenture Stock	85 96	85 96	5 5 8	..	..	..
£3,200	100	..	Do. 7 per Cent. Debentures	.. ..	.. ..	..	—	..	..
			ELECTRICITY SUPPLY COMPANIES.						
1,000	£50	..	City of London Electric Lighting Shares (£25 pd)	32 34	32 34	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	4½ 5	4½ 5	..	..	..	..
5,322	£5	3½%	House to House Electric	4½ 5½	4½ 5½	..	..	..	..
30,000	£5	..	Liverpool Electric Supply (£3 paid)	2½ 2⅝	2⅝ 2⅞	3 13 1	..	..	..
111,000	5	..	London Electric Supply	2⅛ 2⅜	2 2⅛	..	..	..	..
43,900	10/0	2/0	Metropolitan Electric Supply (£9 paid)	9 9½	9 9½	4 5 4	..	9½	..
7,730	£5	..	St. James' and Pall Mall	5⅞ 6⅛	5⅞ 6⅛	—	..	..	..
..	..	..	Do. 7% Preference	⅜ ½ prem.	⅜ ½ prem.	—	..	..	..
42,853	5	..	Westminster Electric Supply (£5 paid)	4⅞ 5⅛	4⅞ 5⅛	..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
63,416	2	..	Brush Electrical Engineering	2⅛ 2⅜	2⅛ 2⅜	..	..	2⅜	..
63,416	2	1/1	Do. 6 per Cent. Preference	1⅝ 1⅞	1⅝ 1⅞	6 8 0	June and December	1⅞	1⅝
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	4 5	4 5	7 0 0	January and July ..	..	..
17,130	5	..	Edison and Swan United	.. ..	.. ..	..	—	..	..
45,000	10	6%	Electric Construction	5 6	5 6	..	—	..	..
70,000	2	10/0	Elmore's Patent Copper Depositing	2 2⅛	2⅛ 3	..	—	2⅞	2⅛
20,000	5	..	Fowler-Waring Cables (£4 paid)	2⅜ 3⅜	2⅜ 3⅜	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	18½ 19⅛	18½ 19⅛	5 2 7	February & August	19⅛	19
£300,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	March & September	..	..
11,334	£10	6/1	International Okonite Limited Ordinary	7⅛ 8⅛	7⅛ 8⅛	11 15 3	..	8⅛	8
11,334	£10	5/0	Do. Preference	9⅛ 9⅝	9⅛ 9⅝	8 4 1	..	..	..
78,949	5	4/10½	Swan United (£3. 10s. paid)	4⅛ 5	4⅛ 4⅜	7 7 4	May and November	4⅛	4⅛
37,350	12	36/0	Telegraph Construction and Maintenance	46 48	46 48	5 0 0	March and July.....	47⅜	46⅛
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	102 105	102 105	4 15 3	January and July .	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£3 paid)	2⅛ 2⅜	2⅛ 2⅜	..	..	..	..
—	£5	..	Do. Preference (fully paid)	3⅛ 4⅛	3⅛ 4⅛	..	..	..	..
			RAILWAYS.						
50,000	£10	..	City and South London Railway	5 6	5 6	..	..	..	..

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

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NOTES.

A commencement will probably be made early next week with the electric lighting of the City, when some five-and-twenty lamps in Queen Victoria-street will be lighted from the Brush Company's temporary station at Bankside. The first instalment of the public lighting plant is now in position, and comprises two 250 H.P. Babcock and Wilcox boilers, and two 40-light Brush machines, rope driven by Raworth engines. As soon as the arc lighting has been started, two 100 kilowatt Mordey alternators and the necessary engine power will be installed for the purposes of private lighting. The permanent station and generating plant are as yet quite *in futuro*, but the ultimate capacity of the Bankside plant will be sixteen 40-lighters and alternators having an aggregate output of 3,000,000 watts; the largest units being 400 kilowatt, and the smallest 100 kilowatt machines. Raworth engines and Babcock and Wilcox boilers will be used throughout, and condensing plant will be erected. We trust that the natural eagerness of the contractors to make a beginning will not result in any untoward mishaps.

On the strength of forty years' experience of coke making, Mr. Steavenson writes to the *Journal of Gas Lighting* to criticise the Presidential Address of Mr. Trewby before the Incorporated Institution of Gas Engineers. With regard to transmission of power, he says that he has found "electricians in such matters very slippery customers," and proceeds to deal in a confused way with "commercial efficiency" and brake horse-power, and says he has "yet to learn of any electrical plant which reaches 50 per cent. in brake horse-power, compared with the indicated horse-power of the engine." Why electrical transmission should be debited with the difference between the brake horse-power and the indicated horse-power of the engine, he does not attempt to explain. With an innocent *non sequitur* he adds, "whereas with gas engines there are well-authenticated cases of 20 cubic feet supplying an actual brake horse-power, which is a very different thing from 'generating an electrical unit'—possibly in the dynamo only." The discussion on a recent Paper "On Electrical Mining Machinery" confirmed our view that electrical engineers are, as a rule, the only ones who really know what efficiency means; and, we would add, that until electrical engineers had shown how to do it, no one had ever measured a horse-power with any approach to accuracy. Unless in the hands of exceptionally skilled engineers, the indicator will not compare for accurate results with the most rubbishy German ammeter or voltmeter. And, lastly, we assert that for high efficiency, and the accuracy with which that efficiency is measured, there is no class of machinery that can compare with the modern dynamo.

While glancing recently at an able Paper on that, to naval minds, engrossing subject of ships *versus* forts, we were glad to find that the author was of opinion that a little less expenditure on big guns and a little more on large search lights would be distinctly advantageous; and the reader was asked to imagine the utter bewilderment of the captain of an ironclad endeavouring to force a narrow passage at night-time in the glare of half-a-dozen well-handled projectors. An involuntary testimony to the value of the search light as a means of defence was, indeed, given but a few weeks since by the loss at Cherbourg of the torpedo-boat "Edmond-Fontaine," which was cut in two by a cruiser whose captain was dazzled by the rays of a search light.

Some little time ago we referred to some facts, published by Mr. F. J. Smith in the *Philosophical Magazine*, concerning the slowness with which small electro-magnets lose their magnetism, after the magnetising current had ceased. In the January number of the same magazine appeared a further communication on this subject, and an apparatus was described for detecting the latency, or the time taken for the magnetism to subside. This time, it seems, can be detected to $\frac{1}{20000}$ of a second; and, although few results are given, it appears that in one experiment a certain iron bar took 0·015 second to lose its magnetism. This time effect is rather important, as it must occur with large magnets as well as small ones, and will take place whenever the magnetising current changes in magnitude. In the field-magnets of dynamos, where the magnetic circuit is very good, we may expect it to be more important still, and may hence prove a difficulty when it is desirable to make the field respond readily to the changes of current strength. The running of large compound dynamos in parallel is sometimes rendered difficult by the slow response of the iron to the magnetising forces, as was pointed out recently in our correspondence columns by Mr. Brew (*The Electrician*, January 2, 1891); and although the greater part of the effect he described is to be sought in the large time constant which the shunt coils of such machines possess, some of it may be due to another cause.

A new determination of "v," the ratio of the electro-magnetic to the electrostatic units, has been recently announced by

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M. PELLAT in the *Comptes Rendus*. The method employed was similar in several respects to one used a year or so ago by Sir WILLIAM THOMSON. A potential difference was measured electrostatically by means of a Thomson absolute electrometer, and electro-magnetically by balancing a known fraction of the voltage against a battery of 13 Latimer Clark cells, the latter being afterwards standardised by passing a current through a known resistance, and an absolute electro-dynamometer, and comparing the voltage set up at the terminals of the resistance with the electromotive force of the cells. Two sets of determinations were made at potentials of 189 volts and 378 volts respectively, and a subdivided megohm was used to fraction down the voltage to that given by the battery of cells. The numbers obtained for "v" were $3{\cdot}0093 \times 10^{10}$ for the first set of experiments, and $3{\cdot}0091 \times 10^{10}$ for the second; and within the limits of experimental error these values are the same as that denoting the velocity of light.

WHILE M. PELLAT can be congratulated upon his skill and patience shown in obtaining so good a result, it is still somewhat open to question how frequently it is desirable in the interests of science to undertake these extremely difficult determinations. A result of this kind, only obtained after three years' careful work, and requiring the highest experimental skill, does not add appreciably to our knowledge. For several previous determinations have shown that the velocity of light, and the ratio of the electric units are represented on the C.G.S. system by the same number to a very close approximation; and until the electro-magnetic theory is further advanced, there is no special interest in finding out whether there is any minute difference between the two. The numbers obtained serve rather as an indication of the accuracy of the various experimenters than as a direct aid to scientific progress. The practical value of the number is very small, as the electrostatic system of units is never used. It would be quite different if the value of a material standard were in question, as for instance in the determination of the ohm. Here it was desirable to obtain the most accurate value possible, and time and skill spent upon the work have been well repaid; although, even in this case, now that the value of the new legal ohm has been finally settled by the Electrical Standardising Committee, it is doubtful whether it is worth while that fresh determinations should be made. The skill needed for them could be far better employed in other directions.

Sir W. Thomson.—To celebrate the admission of Sir. W. Thomson to the freedom and livery of the Clothworkers' Company a dinner was held at the Company's hall, on Wednesday evening, at which the new liveryman was present.

The Porto Rico Cable.—The laying of a cable between Spain and the island of Porto Rico is again under discussion. The Minister for Colonial Affairs has stated in the Cortes that he is considering the conditions on which to invite tenders.

Royal Institution.—At the general monthly meeting of this Institution, on Monday, June 1st, the special thanks of the members were returned to Mrs. Priestley for her donation of £21 to the fund for the promotion of experimental research.

The Telephone in Berlin.—The network of telephone cables already laid beneath the streets of Berlin is estimated to meet the requirements of 30,000 subscribers, the present total being 15,000, or more than the total for the whole of France.

Electrical Bills in Parliament.—On Tuesday last, the Earl of Morley's Committee on unopposed Bills passed the Bill to render valid letters patent to Messrs. Worms and Balé for an improved process and apparatus for tanning by the aid of electricity.

Telephone Trunk Wire Extensions in France.—The necessary money has been voted by the local authorities concerned for the erection of a telephone trunk wire between Paris, Nancy, and Epinal. Nancy is some 190 miles and Epinal some 225 miles from the capital.

Royal Society.—Among the Papers down for reading before the Royal Society yesterday were the following: Prof. O. J. Lodge, "Experiments on the Discharge of Leyden Jars"; Prof. Ayrton, Prof. Perry, and Dr. W. E. Sumpner, "Quadrant Electrometers."

The Berlin Telegraph School.—The course at the Berlin Telegraph School, intended for the instruction of superior officers, includes physics, chemistry, mechanics, mathematics, telegraph construction, commercial geography, commercial law, international law, finance, and political economy.

Eastern and South African Telegraph Company.—Advice has been received of the opening of a telegraph station at Fort Tuli, which is 600 miles north of Kimberley. The British South Africa Company have made arrangements to proceed without delay in continuing the line on to Fort Victoria and thence to Fort Salisbury.

Electrical Communication with Lighthouses.—At several shipping ports a movement has been set afoot in favour of electrical communication being established with the principal lighthouses along the coast. The President of the Board of Trade has consented to receive a deputation on the subject from the Associated Chambers of Commerce on the 12th of June.

Electric Launch on the Lake of Zurich.—The first electric boat on the Continent was launched last month on the Lake of Zürich. It has been built by Messrs. Esscher and Wyss and the Oerlikon firm. It attains a speed of 10 kilometres per hour, and can run five or six hours with one charge of the 56 secondary cells carried.

City and South London Railway.—The fares on this line will in future be—1d. fare up to 8 a.m. between King William-street and the Oval, to and from; and 1d. fare throughout the day from the Kennington, the Elephant and Castle, and the Borough Stations, except between 8 and 10 a.m. and on Sundays and Bank Holidays.

Domodossola.—*L'Elettricita* states that the electric lighting of the streets of Domodossola was inaugurated at the beginning of the present month. The installation, which has been put down by the Society for the Utilisation of Hydraulic Power, is on the series system, a current of 5 amperes at 2,000 volts pressure being generated at some falls on the river Bogna, a mile and a-half from the town.

The Tasmanian Exhibition.—The Tasmanian Exhibition Committee have advised the Agent-General in London that Mr. Pousty, electrical engineer, Launceston, is willing to act as agent for any English firm desiring to exhibit electrical apparatus in the Tasmanian Exhibition. The committee have every confidence in Mr. Pousty's ability as a practical electrician, and reference upon this point is permitted to Sir Edward Braddon, 5, Victoria-street, Westminster.

Telephonic Communication in Yorkshire.—From recent reports of the proceedings of the Leeds Chamber of Commerce, it appears that negotiations have been going on between the Telephone Exchange and the Mutual Telephone Company. An arrangement between the two Companies has now been effected, whereby the interest of the Telephone Exchange is to pass into the hands of the Mutual Company, and steps are at once to be taken by the latter to extend its system to the principal towns of Yorkshire.

Fuel Consumption in Steam Engines.—M. de Swarte has recently read a Paper before the Société Industrielle du Nord de la France, in which he gives an account of the investigations in which he has been engaged for some time, concerning the question whether there is a definite relation between the speed of the piston and the fuel consumption in steam engines. He

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has reached the conclusion that such a relation exists, and that the consumption decreases at an increasing rate when the speed of the piston augments.

Liverpool Corporation Electrical Laboratory.—At a meeting of the Watch Committee of the Liverpool Corporation, on the 25th ult., the city engineer presented a list of candidates for the post of junior assistant to the electric inspector. Thirteen gentlemen had replied to the advertisement, and out of these three had been picked out. The committee unanimously decided to appoint Mr. J. A. Robertson, of Peterborough, to the post. This gentleman is one of Prof. Jamieson's students, and has had the advantage of a training in the laboratories of the Glasgow and West of Scotland Technical College.

Cable and Land Line Interruptions and Repairs.—

Line.	Date of Interruption. 1891.		Date of Repair. 1891.
Mollendo-Arica-Iquique Cable*	Mar. 5	.....	—
Ceara-Pernambuco Cable*	,, 14	.....	—
Assab-Massaouah Cable	Apr. 30	.....	May 4
Aden-Zanzibar Cable	May 11	.....	,, 20
Moulmein-Bangkok Line	,, 13	.....	,, 20
Saigon-Bangkok Line	,, 2	.....	,, 11
,, ,, ...	,, 20	.....	,, 21

* Not yet repaired.

Newcastle.—At a recent meeting of the Town Council a petition to Parliament against the Bill to confirm the Newcastle and District Electric Lighting Company's Provisional Order was presented on behalf of the Town Improvement Committee. It was stated that the principal objection to the Bill was that in its present form the Corporation would not be given the complete control of overhead wires. There would not be the slightest difficulty with the Company in coming to an agreement with the Corporation. The matter was really a fight between the Corporation and the Board of Trade. The Board of Trade wished to intrench upon the Corporation rights. The petition was unanimously ordered to be sealed.

Electric Lighting at Kassel.—The inauguration of the electric light at Kassel took place on the 24th ult. The central station in the town is furnished with power transmitted from turbines five miles distant. The alternating current is used for this transmission, but the alternating motor at the central station drives direct current dynamos, which supply the town on the 3-wire system. An accumulator battery of 100 H.P. has been put down by the Hagen Factory (formerly Müller and Einbeck). Messrs. Siemens and Halske have laid the conductors, and the Oerlikon firm have supplied the dynamos. The whole work has been carried out under the supervision of Herr O. von Müller, the originator of the scheme.

Electric Traction at Minneapolis and St. Paul.—In these two towns, which will shortly possess 230 miles of electric tramways, and which have already a tolerably large mileage, the steam trams, according to local accounts, have been improved out of existence. The *Tribune* of Minneapolis announces that "the steam roads between the two places have made up their minds to withdraw from competition with the electric line, which, though still so recent, has cut into their business to such an extent that nothing is left of it." In view of what has already been accomplished the Electric Street Railway Company is substituting for the 30 H.P. motors others of 50 H.P., which will also haul trailers; and, if necessary, trains will be started from each town every minute.

A Long Run.—In an affidavit, recently sworn before a public notary in the City of London, Mr. C. J. Hall, late manager of the House-to-House Company's station at West Brompton, gives some further particulars with regard to the long run of one of the dynamos at this station, which was alluded to in our issue of February 13th. A set of generating plant was started on the 28th of November last, at 3:45 p.m., and ran without intermission night and day until 9:30 a.m. on the 26th of December. The total length of run was 665¾ hours, the flywheel of the engine made 3,595,050 revolutions, the pulley of the dynamo 15,938,055 revolutions, and the field-magnets travelled a distance of 46,787 miles. The exact length of the run, without the rest of a single second, was 27 days 17¾ hours

An Effect of High Peripheral Velocity.—A Montreal correspondent of *Nature* communicates the following result of an experiment regarding the whirling of steel bands, about which there has recently been some controversy in that journal:—A weldless steel flash, with spherical body 12in. in diameter and ⅜in. thick, constructed for use in a centrifugal milk separator, to revolve about its axis of symmetry at a normal speed of 7,000 revolutions per minute, was whirled at a gradually increasing speed, with a view to ascertaining the "bursting" velocity. At 16,000 revolutions per minute the body of the flash had bulged 2in. in diameter. This is equivalent to an extension of 17 per cent., the peripheral speed being 840ft. per second (about 570 miles an hour), and the tension 31·5 tons per square inch. The experiment was not continued, as it was considered sufficiently satisfactory, and the bulged flash is kept as a curiosity.

The New York Subway Controversy.—Final action was taken last week, says the *Electrical World*, in its issue of May 28th, by the New York Board of Electrical Control in the contest which for years has been carried on between the opposing factions in the electrical world, represented on the one side by the combined electric lighting companies, and on the other by the Western Union Telegraph Company, the Metropolitan Telephone Company, the Edison Electric Company, and the Bell Company, resulting in a complete victory for the latter combination, which, under the title of the Empire City Subway Company, was awarded a privilege which practically will give it full control of all the subways hereafter to be built. The high-tension electric light companies, with a capital of $15,000,000, had been compelled by the exigencies of the occasion to unite for the first time in their history, while their opponents, especially the Metropolitan and Edison Companies, which already virtually own the old subway company, were equally determined.

The Electrical Utilisation of Water-Power.—An important work, says the *Electrical Engineer* of New York, has been undertaken by the South-Western Electric Light and Water-Power Company for the utilisation of water-power situated near Joplin, Mo., for electrical purposes. The scheme includes a fine natural water-power about 5½ miles from Joplin, and when the present installation is completed, will cause about 2,000 effective horse-power to be available. A large concrete dam has been constructed, and the turbines have been built by Leffel and Co., of Springfield, O. These turbines have 66in. wheels, and work under a head of 21ft. The electrical equipment consists of one 1,500-light 2,000 volt alternator and two 50-light arc machines. All the electrical machinery for this installation has been supplied by the Thomson-Houston Company.

Relative Cost of Various Modes of Traction.—A report issued by the United States Census Department has just been published, giving some statistics as to the relative cost in America of the various modes of traction. The report covers statistics of 50 tram lines, 10 of which are operated by cable, 10 by electricity, and 30 by animal power.

	Cable.	Electric.	Horse.
Total Cost of roads and equipment	$26,351,416	$2,426,285	$22,788,277
Cost per mile of road and equipment	$184,275	$36,094	$41,283
Total operating expenses per car mile	14·12 cents.	13·21 cents.	18·16 cents.

The Magdeburg Electrical Testing Establishment.—The electrical testing establishment, which has been in operation for nearly a year, has, says *Industries*, continued to be fully employed up to the present time. Like the association for the inspection of boilers, it undertakes to make for its members yearly inspections of electrical installations. In this way it has accomplished very useful work for the owners of electrical works. Its influence has been the more powerful in consequence of the fact that it is entirely independent of any electrical firm, and can therefore give an unbiassed opinion. The activity of this establishment is felt through-

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out the whole of Germany. Its work consists in examining and reporting on the estimates for electrical installations. It affords advice and information concerning electrical apparatus, and gives its members, by means of circulars, the benefits of the experience which it has gained in carrying out the inspections.

Lightning.—On Wednesday last week a severe thunderstorm broke over Glasgow, about three in the afternoon. The lightning caused some damage in Cathcart, a southern suburb of Glasgow. The Fire Brigade was summoned to Cathcart Public School, where the lightning, by means of an iron pipe communicating with the roof, is stated to have set fire to the furnace-room and melted the pipes. About the same time a one-story building was also struck. A great part of one of the gables was completely demolished, and the upper portion of the chimney was sent through the roof. The zinc piends in connection with the roofing, as well as the rhones, were torn and twisted, and a great number of slates were stripped off. The gas piping was ripped away from the wall, and a sewing machine which had been standing in a corner was thrown into the middle of the kitchen. On Thursday last week the North of England was visited by a severe storm. At Chorlton-cum-Hardy a labourer was killed, and houses were struck by lightning at Rotherham and Masbro'.

Electric Street Railway Litigation in the United States.—The Supreme Court of Michigan recently gave judgment in the case of the Detroit City Railway Company *v.* Mills. The appellants were property owners on an avenue on which an electric road was built, and abetted a movement to cut down the Company's poles, on the ground that the Company were trespassers. The Company secured an injunction, which was made perpetual by the Supreme Court. The judges were of the opinion that the use of streets for street railway purposes does not impose such new burdens, that it is beyond the power of the city to authorise their construction without compensation to adjoining property owners. The Court held, however, that the tracks cannot be constructed in a street too narrow to admit the passage of cars and other vehicles at the same time, that the road-bed and track must be built substantially with the level of the street, so as to permit vehicles to cross without difficulty, and that the poles must be placed so as not to interfere with the right of ingress and egress to abutting property.

Pelton Water Wheels.—Mr. Ross E. Browne, of the University of California, has, according to the *Engineering Record*, published some interesting figures derived from tests of Pelton water wheels made at the University. According to these tests, a wheel 15in. in diameter and 1·5in. wide, working under a 50ft. head, the nozzle being $\frac{7}{16}$in. in diameter, showed an efficiency of 82·6 per cent. When the nozzle was $\frac{3}{8}$in. in diameter, the efficiency was 82·5 per cent. On reducing the head to 8ft. the efficiency was 73 per cent. To obtain a high efficiency with these wheels, Mr. Browne states that the bucket surface at entrance should be approximately parallel to the relative course of the jet, and the bucket should be curved in such a manner as to avoid a sharp angular deflection of the stream. The number of buckets should be small, and the path of the jet in the bucket short to keep down the frictional resistance. The discharge end of the bucket should be as nearly tangential to the wheel periphery as is compatible with the clearance of the bucket. The speed of the buckets should be half that of the jet.

The Sargent Electric Steam Engine Indicator.—In the case of triple expansion engines with indicators placed on the ends of each cylinder it is desirable, in order to obtain accuracy, to indicate the several cylinders at exactly the same instant. With these facts in mind, says the *Electrical Engineer*, of New York, Mr. Frederick Sargent, the well-known electrical engineer of Chicago, has provided a means whereby the recording devices of several indicators can be operated from a distance at the same instant by one person, and the time of contact at each indicator be made of exactly the same duration. The coils of three electro-magnets are placed in series in the circuit of a battery. The armatures of these electro-magnets are fixed upon the movable sleeves of the indicator cylinders, by turning which the pencils are brought into contact with the paper on the drums. The armatures are normally held away from the end of the magnets, and hence, also, the pencils from the drums. When the circuit is closed, however, the sleeves are drawn around, the pencils are pressed against the paper on the drums, and the cards taken.

Electricity and Gas in Factories.—The following quotation from the last report of the Chief Inspector of Factories tells its own story :—"The introduction of the electric light into factories will conduce very much to the healthiness of some occupations, and the comfort of all. Mr. Beaumont, H.M. Inspector for Bradford, has procured the following comparison of the temperature in a wool-combing shed when lighted by electricity and by gas light during 24 hours :—

Time.	Electricity. Deg.	Gas. Deg.	Time.	Electricity. Deg.	Gas. Deg.
7 p.m.	93	95	1 a.m.	96	108
8 p.m.	94	101	2 a.m.	95	108
9 p.m.	94	104	3 a.m.	95	107
10 p.m.	95	106	4 a.m.	95	107
11 p.m.	96	108	5 a.m.	95	107
12 p.m.	96	109	6 a.m.	95	107
Average	95 deg. electricity			105·1 deg. gas	

Wool-combing requires that the machine should be heated, and, as the operations continue frequently night and day, it will be readily conceived what the condition of the atmosphere must be when heated by the machinery and gas."

Platinum in Incandescent Lamps.—The scarcity of platinum has forced lamp manufacturers, says the *Electrical Engineer*, of New York, to exercise the greatest economy in the use of it. In former days two stoutish pieces of platinum were employed, the ends of which extended some distance both inside and outside the sealed portion. To reduce this as much as possible the following method was employed. This consisted in first soldering a comparatively fine short platinum wire to a copper wire, and sealing it in such a manner that the platinum wires extended but a small distance into the seal. The latest method adopted has, however, brought down the amount of platinum required to a still smaller quantity. A short piece of platinum wire is joined to two copper wires, one of which passes into the lamp bulb and the other out to the socket terminal. The glass is sealed around this platinum wire, and for a short distance beyond, covering a small portion of the copper wire. This forms a perfect seal, and, at the same time, reduces not only the length of platinum wire required to $\frac{1}{8}$th of an inch, but, in consequence, also allows of considerable reduction in its cross section.

Electrical Safety Apparatus for Miners' Cages.—At the general meeting of the Federated Institution of Mining Engineers, on Friday, May 29th, Mr. John Yates read a Paper on "An Electrical Safety Apparatus for Cages." He said that, although great advances had been made in recent years in nearly every branch of mine engineering, we were no better off to-day for a reliable safety cage than we were 20 years ago. According to the reports of Her Majesty's Inspectors of Mines there were, between the years 1880-1890, no less than 45 fatal accidents, resulting in 87 deaths, caused by the breaking of ropes and chains in shafts. Experience had shown that an apparatus which acted indirectly through the medium of a spring or otherwise was not to be relied upon. For some time past he had been at work on the matter, and the result of his labours had been the invention of an apparatus which appeared to promise safety in case of breakage of rope. The principle of his invention was to use the hauling rope as the means for conveying a current of electricity to four electro-magnets with the cage, each of the magnets sustaining a gripping cam. On the fracture of the rope and the breaking of the current, the cams would drop into play against the guides.

Repairing Incandescent Lamps.—How to turn broken filament lamps to good account has long been an object with lamp makers and others. According to M. A. Hess, in *La Lumière Electrique*, a good commercial method of renewing used-up incandescent lamps has been devised by M. Pauthonier. A hole is cut in the top of the glass bulb, the broken filament is taken out, and the carbon deposited on the interior of the glass is removed. A new filament is then introduced, and the bulb is filled with a liquid hydro-carbon. The ends of the new

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filament are pressed against the stumps of the old one by pliers, the arms of which, insulated from each other, serve as conductors for the current, which, passing from one arm to the other at the juncture of the carbons, decomposes the hydro-carbon, and gives rise to a dense deposit, which firmly seals the ends together. The resistance of the new filament is not affected by being placed in the hydro-carbon, since it is not traversed by the current. The renewed lamp is then dried, exhausted, and sealed in the ordinary manner. The saving effected is said to amount to 75 per cent., being the difference between 1fr. 40 centimes, and 35 centimes.

Taunton, West of England, and South Wales Electrical Engineering Exhibition.—An Electrical Engineering Exhibition will be opened, in Taunton, on August 1st, closing on October 31st, on the grounds adjoining the Taunton Electric Lighting Company's central station in St. James'-street. The Exhibition will be opened daily from 2 p.m. to 10 p.m. Taunton being the centre of the West of England and South Wales district, situated on the main line of the Great Western Railway, and the junction of four branch lines of railway, it is anticipated that there will be a large attendance. It is proposed to run an electric omnibus between the Exhibition and the railway station during the time the Exhibition is open, and to place one or two electric launches on the river Tone. Exhibitors must run their own wiring over the space allotted to them. Electrical energy will be provided at 4½d. per Board of Trade unit. The charge for space will be 2s. 6d. per square foot. All exhibits must be in order by July 27th. Applications for space must be made on the printed forms, to be obtained from the Manager and Secretary, Bath Electric Light Works, Bath, which must be filled up and returned on or before the 30th inst.

The Underground Main Question.—To every question there are at least two sides, says *Modern Light and Heat*, one of which is bright, the other gloomy. So long as the former is visible, all is apparently well; but when the other side comes into view it is not so pleasant. The bright side of the municipal lighting and underground wire question has evidently been so long dazzling that many of our municipal bodies have been unable to look at it from but one standpoint, and have acted accordingly. In some cases the best results have not been attained. For instance, some time ago, the city of Indianapolis thought it was the proper thing to compel electric light wires to be placed underground, and they were so placed. A private corporation was doing the lighting, so that the city had to go to no expense. Now the dark side of the question looms up because the city fathers think that there ought to be more and cheaper lights; but the fact that an ordinance has been passed, forbidding the use of overhead wires for arc and incandescent lighting, prevents the accomplishment of this result, unless the ordinance be repealed. Underground conduits for electric wires are by no means such inexpensive luxuries as people are wont to imagine; and certainly, unless a company were assured a long franchise and a large business, it could not afford to come into a city where it was necessary to place the wires underground.

Wheatstone's Determination of the Velocity of Electricity.—In the Paper on the Motion of Electricity in Wires, Kirchhoff, in 1857, first showed that under certain conditions electricity moves in a thin wire according to the laws of wave-motion, and with a velocity equal to that of light. The agreement between the velocities of electricity and of light only holds, however, when electricity travels in a straight wire stretched in the air. If we apply the bases of his calculation to other cases, for instance, a wire which is bent backwards and forwards in zigzag or is wound in a spiral, it is found that electricity travels under these conditions with a far greater velocity. In Wheatstone's well-known method 20 plane windings of drawn-out wire were used, and the velocity of electricity was found by this measurement to be half as much again as that of light. In the preceding, says Prof. J. Stefan, in a recent number of the *Wiener Berichte*, I think I have given the correct explanation of this result. I have, however, also attempted to give this explanation an experimental basis, and for this purpose I have employed the method given by Hertz of producing stationary electrical waves in wires. I have used a similar conductor to that of Wheatstone, but on a smaller scale, and connected it with a couple of long straight wires, and compared the length of a wave in the conductor with the length of the same wave in the straight wires. The wave in the conductor is considerably longer, and in accordance with this the velocity of electricity in the conductors is greater than in the straight wires, and, according to my experiments, in a ratio which even exceeds that found by Wheatstone.

Dynamo Telegraph Plant at St. Louis.—In the Western Union Company's new central office at St. Louis the current is entirely supplied by dynamos. The engine and dynamo room is 36 by 47ft., and contains three 15 H.P. Rice engines. Each engine is belted to a separate shaft, to which is belted a group of five or seven telegraph dynamos. The shafting is supported entirely independently of the building, to prevent noise or vibration being communicated to it. The 19 telegraph dynamos are supplied by the C. and C. Electric Motor Company, and are arranged in two groups of seven and one group of five. The two groups of seven are each divided into sections for supplying main line, local, and loop circuits. Five dynamos of each group are connected in series and supply the main lines, the sixth dynamo supplies the loop circuits, and the seventh supplies the local circuits. The third group of five dynamos is a reserve main line set, all five being connected in series. The dynamos are wound for a potential of 80 volts, but ordinarily will be run at 70 volts. A set will, therefore, give the following potentials: 70, 140, 210, 280, and 350 volts. The loop dynamos are wound for 30 volts, but will be run at 25 volts. The local circuit dynamos are wound for 10 volts, and will be run at 6 volts. The current capacity of the dynamos is as follows: Main line dynamos, 20 amperes; loop dynamos, 50 amperes; and local dynamos, 150 amperes. The fields of the series dynamos of each set are excited by the seventh dynamo, each field having a regulating resistance in circuit with it, giving independent regulation for each dynamo. Regulation can also be effected by changing the potential of the exciting dynamo.

City and Guilds of London Institute.—The following facts and figures connected with this Institute taken from the last report of the Council may be of interest. Both at the Central Institution, and at Finsbury College, the electrical department proves by far the most attractive, but the Council are of opinion that "although the success of this department cannot but be a source of satisfaction, it has been to some extent at the expense of the Chemical Department." The total number of students attending all four departments at the Central Institution during 1888–89 was 82, and 107 during 1889-90; for the winter term 1890-91, the figure is 140, and, including the regular students not attending all four departments, the total is 156. The amount voted by the Council for the Central Institution at the beginning of last year was £8,180, and the students' fees amounted in round numbers to £3,778, making a total of £11,952; the gross expenditure was £10,673, the *net* cost, after deducting the amount of students fees and other items, comes out at £6,677, which, taking the average number of regular students during 1890 at 140, amounts to £47. 14s. per regular student. At Finsbury Technical College during the last session the day classes were attended by 180 students, of which 95, or nearly 53 per cent., belonged to the electrical department. At present there are in all 184 day students, of which no less than 99, or 53·8 per cent., attend the electrical department. Some 1,164 evening class tickets were sold to 972 students; the number of tickets taken by apprentices under 20 years of age was 259, or about 22 per cent. of the total issue. The amount voted by the Council for the maintenance of Finsbury College during 1890 was £5,877, students' fees amounted to £2,820, making a total of £8,697. The gross expenditure has been £8,564, and the net expenditure £5,582, deducting from this sum the £275 for electric light extension, and taking the average number of day students during 1890 at 182, the net cost per day student comes out at £29. A sub-committee appointed in July, 1889, with reference to the completion of the equipment of the Central Institution recommend an expenditure of £5,100 for this purpose. The total sum expended by the City Companies upon the City and Guilds of London Institute since its foundation in 1878 amounts to £352.543.

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MAGNETISM IN IRON AND OTHER METALS.*—XLI.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 8.*)

§ 143. Strain caused by Magnetisation.—Closely associated with the changes of magnetisation that are caused by strain are the changes of form which a piece of iron, or other magnetic metal, is observed to undergo when it is magnetised, or when its magnetism is changed. The fact that strain alters magnetism involves this converse, that change of magnetism is accompanied by strain.† The earliest experiments on the subject were those of Joule,‡ who found that the length of a soft iron rod was increased by the application of magnetising force, within the limits of force to which his experiments extended. The extension was accompanied by lateral contraction, with the result that the volume of the rod did not sensibly change. To show this, the experiment was made of magnetising the rod within a tube full of liquid, which was closed, except for an extended portion with a narrow bore, the rise or fall of the liquid in which would have indicated any change of volume on the part of the iron. Later experiments on the extension of rods were made by Mayer,§ who dealt specially with steel; and by Barrett,‖ who extended the inquiry to nickel and cobalt, finding that nickel retracted when magnetised. It is unnecessary for our purpose to refer to these early experiments in detail, for in recent years the matter has been exhaustively examined by Shelford Bidwell, whose results have

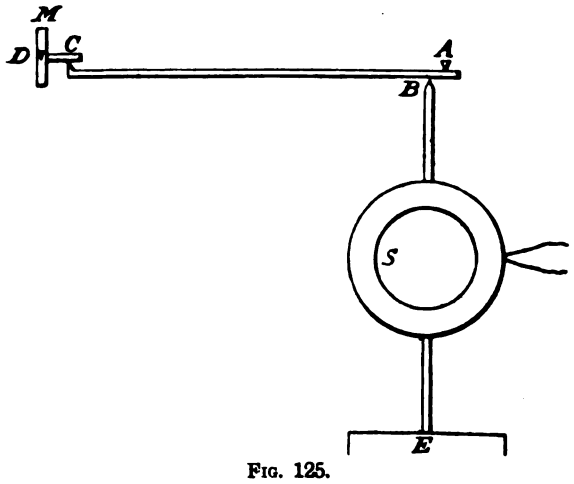

FIG. 125.

harmonised much that was apparently contradictory in the statements of previous investigators. Dealing with rings as well as rods (to secure uniform magnetisation and determinate magnetising forces), Bidwell has tested iron, steel, nickel, and cobalt throughout a very wide range of magnetising force, and has found that when the force is pushed to high value the character of the action becomes greatly changed. He has also examined the modifying influence of externally imposed tensile stress on the change of length caused by magnetisation. The following is a brief summary of the more important of his results¶:—

The method of experiment is shown diagrammatically in Fig. 125, where S is the ring to be tested. The change of length along the lines of magnetisation was deduced by observing the change in the diameter of the ring which occurred when the magnetising current was applied. The ring S was placed between a fixed support E, and a long lever B, pivoted on a fixed fulcrum at A. The long end of the lever at C tilted a small mirror M hinged on a fixed support by a knife edge at D. The deflection of the mirror was read by means of a distant scale, the sensibility of the arrangement being such that readings could be taken corresponding to about one ten-millionth of the length of the specimen. The ring was jacketed with wood to exclude, as far as possible, the heating effect of the magnetising coil, and with the same object the circuit was never allowed to remain closed for more than a fraction of a second. A similar arrangement was used for tests of rods. The ring or rod was first demagnetised by reversals, then a current of known strength was passed for a moment through the magnetising coil and the deflection was noted, the dead-beat character of the apparatus allowing this to be done almost instantaneously. Then the specimen was again demagnetised and another current was

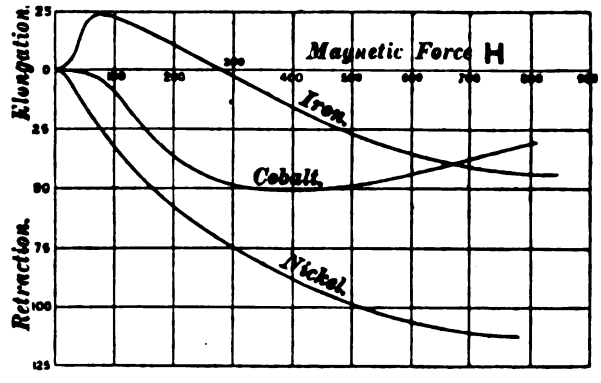

FIG. 126.—Elongation and Retraction of Iron, Nickel, and Cobalt through Magnetisation (Bidwell). The elongations and retractions are stated in ten-millionths of the length.

applied, and so on. In some of the experiments magnetising forces approaching 1,500 C.-G.-S. units were employed.*

Beginning with small magnetising forces, Bidwell found his iron rods and rings elongate when magnetised, by amounts which appear to increase at first in something like simple proportion to the degree of magnetisation. But as the magnetising force increases, the elongation of iron passes a maximum, becomes reduced, and vanishes when the magnetising force is about 300 C.-G.-S. With higher forces still, the iron retracts instead of elongating when the magnetising force is applied, and this retraction appears to tend to a finite limit as the force is further increased. The maximum amount of elongation, which is observed in comparatively moderate fields (say about 100 C.-G.-S.), varies in different specimens; it ranged in Bidwell's experiments from about $\frac{1}{200,000}$ to $\frac{1}{400,000}$ of the length. The amount of retraction under very strong force may be as much as $\frac{1}{130,000}$

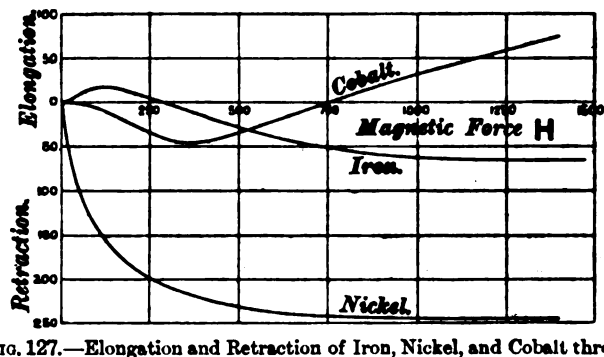

FIG. 127.—Elongation and Retraction of Iron, Nickel, and Cobalt through strong Magnetisation (Bidwell). The elongations and retractions are stated in ten-millionths of the length.

of the length. These figures refer to iron. Steel behaves in much the same way, but suffers less elongation than iron under moderate forces.

In nickel, on the other hand, there is retraction from the first, and the amount apparently tends to a fixed limit as the magnetising force is raised to high values.

In cobalt the action is less simple. Weak magnetising forces cause sensibly no change of length. Stronger forces cause retraction, but the amount of that passes a maximum, and

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† See Prof. J. J. Thomson's "Applications of Dynamics to Physics and Chemistry," Chap. IV,

‡ Joule, *Phil. Mag.*, 1847., Vol. XXX., pp. 76, 225. Reprint of Papers, p. 235.

§ Mayer, *Phil. Mag.*, Vol. XLVI. p. 177

‖ *Nature*, 1882, Vol. XXVI., p. 585

¶ Shelford Bidwell, *Proc.* Roy. Soc., 1886, Vol XL., pp 109 and 257; *Phil Trans.*, 1888, p. 205; *Proc.* Roy. Soc., 1890, Vol. XLVII., p. 469.

* *Phil. Trans., loc cit.* p. 227.

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vanishes with further increase of the force, after which, with stronger force still, there is *extension*, the amount of which was still increasing fast in the strongest field to which the experiments were carried. These results are well shown by Figs. 126 and 127, taken from Bidwell's principal paper. In Fig. 126 the magnetic force ranges up to 800 units. In Fig. 127 it is carried to nearly twice that value. The specimens of metal tested were different in the two cases. The general results, however, agree well. The nickel used in the experiment of Fig. 126 shows more retraction than the other. The amount of retraction under the strongest magnetic force is about $\frac{1}{10,000}$ of the original length.

§ 144. **Modification of the Results by applying Tensile Stress.**—In a later Paper, Bidwell has described experiments made with rods of iron, nickel, and cobalt, in which the change of length caused by magnetisation was made to take place while a load was hanging from the specimen. The results for iron are shown in Fig. 128, the numbers attached to the curves being the values of the externally applied stress in kilogrammes per square cm. The effect of tension in iron is to lower the curve, reducing the maximum extension which magnetisation causes, and finally making it vanish. Under the greatest loads used in these experiments, the iron retracted from the first as the magnetising force was increased.

In nickel the effect of tensile stress is to raise the curve in its earlier stages, making the amount of retraction caused by magnetisation less if the test is made while there is pull, than if it is made while there is no pull. This applies to magnetising forces of moderate strength. But in stronger fields the

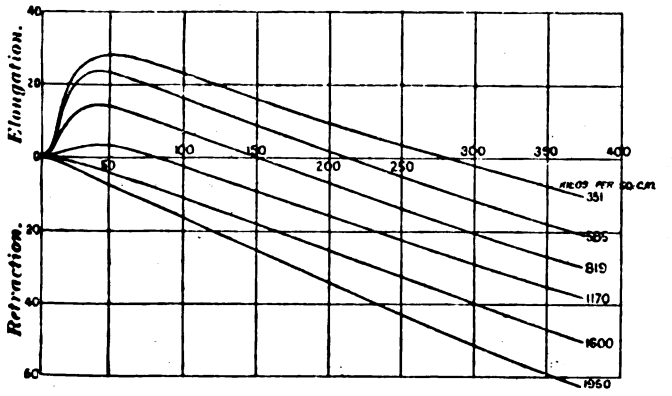

Fig. 128.—Changes of Length caused by Magnetising Iron under various amounts of longitudinal pull (Bidwell). The elongations and retractions are stated in ten-millionths of the length.

magnetic contraction is increased by the presence of small amounts of pull, and decreased by the presence of large amounts of pull.

In cobalt, the changes of length which the metal undergoes in being magnetised were found to be almost, if not quite, independent of the presence of pulling stress. Cobalt stands in striking contrast in this respect to iron and nickel, in both of which the modifying influence of pull is conspicuous.

§ 145. **Internal Stress in a Magnetised Rod or Ring, due to the Magnetisation.**—Some part of the retraction which is observed in experiments such as these is to be ascribed to the state of internal stress into which the metal is thrown by its magnetisation. Imagine a cross-section to be taken through the substance of a ring or very long rod, the intensity of magnetism in which is I. The surfaces which are opposed to each other at the imaginary plane of section act as a pair of plates of attracting matter, the surface density of which is I. The force which either exerts on unit quantity of the other is (by a well-known proposition in the theory of attraction) $2\pi I$. But there are I units of attracting matter per unit of area of the plate, hence the whole force exerted by one plate on the other is $2\pi I^2$. This is the stress between the two, existing in virtue of the magnetisation, and the same stress exists at every imaginary surface of section. In other words, there is an internal stress which tends to contract the length of the piece, the intensity of which is $2\pi I^2$ in dynes. To find the amount of the contraction per unit of length which this internal stress will cause, we have only to divide the intensity of this stress by Young's modulus for the material, also expressed in dynes. Young's modulus for iron is about $1{\cdot}8 \times 10^{12}$ dynes. To see what is the greatest amount of contraction which can in any case be attributed to the cause referred to here, we may take for I its limiting value in iron, namely, 1,700 (see § 98), and the result is $\frac{2\pi \times 1{,}700^2}{1{\cdot}8 \times 10^{12}}$ or $\frac{1}{1,000,000}$ very nearly. In the experiments which have been described, I did not, of course, reach so high a value as 1,700. It is clear, then, that the effect in question is at least of the same order of magnitude as the contraction which actually occurs in iron. Bidwell, who has discussed the matter from the same point of view, has, however, come to the conclusion that the internal stress due to magnetisation is by no means the sole cause of the retraction which iron undergoes when it is strongly magnetised. Comparing the values of the retraction at two points in his curve, just when retraction has begun to take the place of extension with the values of the internal stress as measured by the force required to separate two portions of a divided bar magnet, he contends that the difference in the amount of internal stress accounts for only about one-fifth of the actual change of length.*

(To be continued.)

* *Proc.* Roy. Soc., 1890, p. 469.

ON ALTERNATE CURRENT THEORY.

BY W. E. SUMPNER, D.SC.

The sine function has been much abused by writers dealing with alternate current theories, but several cases could be pointed out in which those who have been very free in expressing dissatisfaction with it have afterwards felt forced to use it extensively. It is, no doubt, true that alternating currents sometimes vary in a manner very different from an ordinary sine law, but this is no real reason why the sine function should not be used for purposes of calculation; and, in the writer's opinion, most of the errors to which its use has led have been due, not to any inability of the sine function to truly represent the essential facts of the case, but rather to the circumstance that the meaning of the quantities involved in the equations have been frequently misunderstood. The simplest periodic function is the sine, and any attempt to replace it must lead to greater complication; while graphical or geometrical methods are either too slow, or require too much care in drawing, to be of much service, however admirable they may be for clearly representing the nature of the reactions going on. Our endeavour should, therefore, be to find out how to use the sine function so as to introduce no error into our calculations when the current and potential variations do not follow a strict sine law, and it is in the hope of aiding in this search, and with the view of pointing out some mistakes which are often unconsciously made, that the present article is written.

In dealing with electricity from an engineering point of view, there are three quantities, all of equal importance, which have to be considered. These are voltage, current, and electrical power. The two former determine the condition of supply, while the latter denotes the output. When the currents are steady a very simple relation connects them, for if W is the output in watts of a current, A amperes at voltage V, we have $W = V A$. This equation is, however, not necessarily true of varying currents, and, in fact, it is meaningless till the values of V and A are defined. The definitions adopted depend on the heating caused by the passage of electrical currents; a varying or alternating current being said to be equal to that steady current which would produce the same amount of heating in a non-inductive resistance, and a similar definition being employed for potentials. As the rate at which heat is generated in a non-inductive wire of constant resistance is propor-

* Bidwell; *Phil. Trans.*, 1888, pp. 217-218.

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tional to the square of the current, or voltage, applied, these definitions are accurately represented by the equations,

$$\left.\begin{aligned} A^2 &= \frac{1}{T}\int_0^T A_t^2\,dt \\ V^2 &= \frac{1}{T}\int_0^T V_t^2\,dt \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad (1),$$

in which A_t is the instantaneous value of the current at the time t, A is the nominal value of the current as read by an alternating current ammeter, and

$$R\,A^2\,T = \int_0^T R\,A_t^2\,dt \quad . \quad . \quad . \quad . \quad . \quad (2)$$

is the heat generated by the passage of this current through a wire of resistance, R, during a time, T. Similarly we have $A_t = \frac{V_t}{R}$, and $A = \frac{V}{R}$, if the wire is non-inductive, and, accordingly, the last equation may be written

$$\frac{V^2}{R}\,T = \int_0^T \frac{V_t^2}{R}\,dt \quad . \quad . \quad . \quad . \quad . \quad (3).$$

If W_t is the instantaneous value of the rate at which energy is being transferred,

$$W_t = V_t\,A_t,$$

and W, or the average power in watts, is such that

$$T\,W = \int_0^T V_t\,A_t\,dt; \text{ or } W = \frac{1}{T}\int_0^T V_t\,A_t\,dt \quad . \quad . \quad (4).$$

If the power is being supplied to a non-inductive resistance, R, we have $V_t = A_t\,R$ and $W = V\,A$, just as if the currents were steady, but in general this will not be the case, and we shall have

$$W = V\,A\,\eta \quad . \quad . \quad . \quad . \quad . \quad . \quad (5);$$

where η is some numerical factor, whose value depends on the way in which the currents and potentials vary. The value of the quantity η is of the greatest importance, and it is easy to show that it can never be larger than unity, although it is equal to one when the resistances are non-inductive. In proving this, it is not necessary to assume that the currents vary according to a sine law; all that we need suppose is that the values of V_t and A_t vary in the same sort of way, and then it is evident that the value of the integral (4) must be greatest when the maximum values of V_t and A_t occur simultaneously. If, however, this is the case, V_t and A_t are approximately proportional to each other at every instant, and under these circumstances we shall have

$$W = V\,A,$$

or $\eta = 1$. The maximum value of η is therefore unity, and this fact we may very conveniently express by the equation

$$\eta = \cos\theta \text{ or } W = VA\cos\theta \quad . \quad . \quad . \quad . \quad (6),$$

where we may define θ to be the *difference of phase*, or lag, between the volt and ampere curves. The angle θ has a very definite meaning when the current variations can be assumed to follow a sine law, since it is directly proportional to the time elapsing between the moments at which the current and potential attain their maximum values. For this reason it is preferable to consider η in equations (5) and (6) as being the cosine of an angle rather than as a proper fraction, but in doing so it is well to notice that no assumption has been made regarding the way in which the currents change. In practice, θ is small, and cos θ is very nearly unity, except for highly inductive resistances. For the primary coils of small transformers, whose secondary coils are open circuited, θ lies between 30 and 50 degrees, and cos θ varies from ·9 to ·6. For large unloaded transformers, for well-made choking coils, and for condensers absorbing very little energy in heat, the angle θ may be as much as 80° (cos 80° = 0·17), and in very exceptional cases 85° (cos 85° = 0·087), so that the quantity η may vary from 0·1 to 1, although when large amounts of power are being transmitted, cases in which η is as small as 0·9 are rare.

A conductor through which a steady current A is flowing requires to be subjected to a voltage $V = R\,A$, where R is the resistance of the conductor as determined by the Wheatstone Bridge. The value of R is of course constant, so that if A is doubled V is also doubled. With alternate currents this equation between V and A no longer holds, but we have

$$V = I\,A \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7),$$

where I is called the impedance of the conductor, and is a quantity whose value may be stated in ohms just like an ordinary resistance. In nearly all cases, too, the value of I is the same whatever the value of A, provided the current frequency remains the same, although this is not strictly true when the conductor surrounds, or is in the neighbourhood of, masses of iron. With alternate currents of ordinary frequencies I may very much exceed R. In all cases the product $A^2\,R$ measures the rate at which energy is used up in the conductor as heat; but whereas this product denotes the whole power absorbed by the conductor when A is a steady current, the power supplied by an alternating current to the same conductor may far exceed this quantity, owing to inductive effects in neighbouring circuits and other causes. Suppose X is the number of ohms that has to be multiplied by the square of the current to obtain W, the watts absorbed by the conductor, then

$$W = A^2\,X \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8),$$

but by (6) and (7),

$$W = V\,A,\ \cos\theta = A^2\,I\cos\theta,$$

or

$$X = I\cos\theta \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9);$$

and if we define a new quantity Y by the equation

$$Y = I\sin\theta \quad . \quad . \quad . \quad . \quad . \quad . \quad (10),$$

we shall have

$$I^2 = X^2 + Y^2$$

$$\tan\theta = \frac{Y}{X},\ \sin\theta = \frac{Y}{I},\ \cos\theta = \frac{X}{I} \quad . \quad (11).$$

There are thus four distinct resistances, or rather ohmages, to be considered in connection with any conductor subjected to alternate currents. These we have distinguished by the letters R, I, X, and Y. The two former have well-known names, but the two latter are not recognised. The first of these quantities, R, is the resistance of the metallic conductor, and is the most definite and constant of them all, but it is also usually the one of least importance. The impedance I, as we have said, is approximately a constant for a given frequency of the current, but the values of X and Y may vary considerably as the current changes, even although the frequency remains the same. In much that has been written about alternate currents the quantities R and X have been frequently confused together, although it is well known that the power absorbed by a conductor may, with alternating currents, greatly exceed that lost in heating the wires through which the primary current passes. The value of Y, too, has been frequently estimated far too high, in consequence of the fact that X has been estimated too low.

It seems, therefore, desirable to point out the meaning of these quantities in certain simple cases, and to show, by actual reference to figures, the character of the variations to which their values are subject.

Hitherto we have made no assumption about the way in which the current changes occur, and in what follows the results given will be equally true whether the currents are sinuous or otherwise; but we shall now find it convenient, for the sake of definiteness, to assume that the currents and potentials vary according to a simple sine law. Moreover, as the considerations we have alluded to were very fully discussed in a rather lengthy Paper, entitled "Interference with Alternating Currents," by Prof. Ayrton and the present writer, and which, although read before the Physical Society in March last, has not yet been printed, it may be of interest to publish here the following short extract bearing on these questions:—

"Suppose $A_t = A_0$, $\sin p\,t$ is the value of the current flowing at any instant in a coil of wire whose resistance is R and whose self-induction is L. The potential V_t at the ends of the coil will be

$$V_t = R\,A_t + L\frac{d\,A_t}{d\,t} \quad . \quad . \quad . \quad . \quad . \quad (12),$$

$$= R\,A_0\sin p\,t + L\,p\,A_0\cos p\,t,$$

$$= \sqrt{R^2 + L^2\,p^2}\ A_0\sin(p\,t + \theta),$$

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where $$\tan\theta = \frac{Lp}{R} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (13);$$

and if V and A are the values of the voltage and current, as read by alternate current instruments,

$$V = IA \qquad \text{where } I^2 = \sqrt{R^2 + L^2 p^2} \quad . \quad . \quad (14);$$

moreover, if W is the power in watts absorbed by the conductor, that is the mean value of the product $V_t A_t$,

$$W = \frac{1}{T}\int_0^T V_t A_t \, dt \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (15),$$

$$= \frac{1}{T}\int_0^T [R A_0^2 \sin^2 pt + Lp A_0^2 \sin pt \cos pt] \, dt$$

$$= R A^2.$$

The value of L is assumed constant, so that the second term vanishes in the integral, which is taken over the period τ of the alternating current. This case is, however, the simplest which can arise, and all the inductive conductors occurring in practice possess iron cores which absorb power in hysteresis or eddy currents, or transfer energy to secondary coils. Considering first the case of a transformer whose core gives rise to no dissipation of energy, equation (12), suitably modified, may be written

$$V_t = R A_t + L\frac{dA_t}{dt} + M\frac{dB_t}{dt} \quad . \quad . \quad . \quad (16),$$

where M is the mutual induction between the coils, and B_t is the current flowing through the secondary. When this value of V_t is substituted in equation (15) the value of W is found to exceed RA^2 by the power transferred to the second coil. The values of L and M are known to vary with the value of A, the current in the primary coil, but may be assumed to be constant throughout the period. In order, however, to account for the fact that the core itself absorbs heat owing to hysteresis and eddy currents, it becomes necessary to assume that these coefficients vary during the period; and, under these circumstances, it may well be questioned whether the method of analysis by means of these coefficients, as exemplified in equation (16), and so frequently resorted to by writers on alternate currents, is either useful or correct. It is far preferable to write equation (16) as follows:—

$$V_t = R A_t + \frac{dN}{dt} \quad . \quad . \quad . \quad . \quad . \quad (17),$$

where $\frac{dN}{dt}$ is the induced electromotive force generated by the lines of force cutting the primary coil. Since each of the quantities V_t and A_t is assumed to be a sine function, $\frac{dN}{dt}$ must be so likewise, and its value, like that of V_t in equation (12), may be expressed as the sum of two rectangular components

$$\frac{dN}{dt} = X_n A_0 \sin pt + Y_n A_0 \cos pt \quad . \quad . \quad (18),$$

of which the first, $X_n A_0 \sin pt$, is in phase with the current $A_t = A_0 \sin pt$, while the second differs in phase from it by a quarter of a period.

Equations (17) and (18) combine to the following:

$$V_t = (R + X_n) A_0 \sin pt + Y_n A_0 \cos pt,$$

and, comparing this with equations (12) and (15), we notice that $R + X_n$ takes the place of R, and Y_n replaces Lp. The power absorbed is measured by $R + X_n$, and the former of these quantities denotes the power wasted in heating the primary coil, and the latter the power transferred to the core, or secondary circuit. In general, whatever the nature of the conductor may be, if $A_t = A_0 \sin pt$ and $V_t = V_0 \sin(pt + \theta)$, the quantities which replace R, and Lp in (12) are X and Y, where

$$X = \frac{V_0}{A}\cos\theta \qquad Y = \frac{V_0}{A}\sin\theta,$$

and $$X^2 + Y^2 = \frac{V_0^2}{A^2} = I^2.$$

The use of the quantities X and Y seems preferable to that of coefficients of induction, for several reasons. They are just as easily found experimentally, and have a more tangible meaning. Indeed, the values of X and Y have always to be found before the values of the coefficients usually employed can be determined. Their values are expressed in ohms just like resistances. X is directly associated with the power which is being withdrawn from the source, and Y represents the power which corresponds with the magnetic changes going on, but which is not permanently absorbed. Although X and Y vary as the currents change, yet they do not vary more than the coefficients themselves.

The way in which these quantities vary in the case of a transformer is best indicated by reference to a few actual measurements. When the secondary circuit of a particular transformer was open, the primary coil was found to take a current of 0·86 amperes under a pressure of 60 volts. At the same time the power absorbed was found, by a voltmeter method we have devised, to be 43·3 watts.

Hence $$X = \frac{43{\cdot}3}{{\cdot}86 \times {\cdot}86} = 59 \text{ ohms};$$

$$I = \frac{60}{{\cdot}86} = 70 \text{ ohms};$$

$$Y = \sqrt{I^2 - X^2} = 37{\cdot}6 \text{ ohms}.$$

The angle of lag between the volts and amperes, as calculated from the formula $\cos\theta = \frac{X}{I}$, comes out to be about 33°. The resistance R of the primary coil, as measured by the Wheatstone's Bridge, was only 0·08 ohms, so that X is more than 600 times as great as R, and if $\cos\theta$ had been calculated from the formula $\cos\theta = \frac{R}{I}$, which is incorrect, but frequently relied upon, the value of θ would have been estimated quite wrong. When the above transformer was working at full load, so that the primary current was 15 amperes, the angle of lag was quite inappreciable, and

$$Y = 0$$

$$X = I = \frac{60}{15} = 4 \text{ ohms}.$$

Each of the quantities X, Y, and I, diminishes as the load on the transformer increases. The value of I for a constant potential transformer is, of course, inversely proportional to the current in the primary circuit."

From some numbers recently published by Dr. Fleming in his Paper, just read before the Institution of Electrical Engineers, it is possible to point out a very remarkable example of the great differences in the values of the quantities we have represented by X and R, although these quantities seem to be regarded as identical by many who have written on alternate currents, since the fact that they differ has not been alluded to. According to Dr. Fleming, the resistance of the 10,000-volt coil of one of the 150 H.P. transformers in use at Deptford is 3·5 ohms, and when the low-pressure coil is delivering no current, the current in the primary is only 0·4 amperes. The value of X must, therefore, be such that $(0{\cdot}4)^2 X$ is equal to the power wasted in the core, estimated in watts. This waste is probably not less than 2 per cent. of the full load, but assuming that it is only 1 per cent., or 1·5 H.P., we have

$$X = \frac{1{\cdot}5 \times 746}{{\cdot}4 \times {\cdot}4} = 7{,}000 \text{ ohms},$$

$$I = \frac{10{,}000}{{\cdot}4} = 25{,}000 \text{ ohms},$$

$$Y = 24{,}000 \text{ ohms},$$

and the angle of lag θ, whose tangent is Y/I, is about 74 deg. The value of X is thus no less than 2,000 times the resistance (R = 3·5) of the primary winding, and even when the full load current is on the ratio is still extremely large.

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THE FRANKFORT ELECTRICAL EXHIBITION.

(FROM OUR OWN CORRESPONDENT.)

Messrs. SCHUCKERT and Co. have within the last few days made great progress with their installation, and it will shortly be quite complete. Like Messrs. Siemens and Halske, this firm is erecting a central electric lighting station. The plant includes a dynamo, coupled direct to a two-cylinder condensing engine by Kuhn of 250 to 300 H.P., the initial pressure being about 120lb., and the engine running at 160 revolutions; and a 100 H.P. compound engine, coupled to a dynamo used for charging the accumulators belonging to the central station. There are also a 100 H.P. machine, by Woolf, of Nuremburg, driving two dynamos (direct and alternating) for the transmission of power, and a 30 H.P. Dävel engine, coupled direct to a dynamo supplying the search lights which have been installed in a tower in the Exhibition grounds. In the building devoted to matters connected with railways and tramways, Messrs. Schuckert and Co. show a model lighting truck. They have also undertaken the execution of the electric tramway, on the closed-conduit system, to the river Main, and are erecting a station in the Palm Gardens, from which the power will be transmitted to the Exhibition.

The COLOGNE ACCUMULATOR WORKS, of Hagen, have a complete central lighting station for 500 glow lamps, consisting of a 20 H.P. steam engine, a compound-wound dynamo (200 amperes × 65 volts) by Lahmeyer, a dynamo giving 200 amperes at 25 volts, and a 36 cell accumulator battery. They also exhibit a battery of 52 cells, used by the Helios Company, of Cologne, which have a capacity of 1,080 ampere hours.

POKORNY and WITTEKIND, of Frankfort, who occupy a position near the middle of the Machinery Hall, have at present two dynamos running. One of 60 H.P. is driven by a horizontal single-cylinder steam engine, ropes being in this case substituted for the driving strap; the second is a 40 H.P. dynamo, driven by a high-speed single-cylinder engine. Among other dynamos not yet in operation are two interior pole machines, each of about 16 kilowatts, and two direct-current dynamos for lighting and for transmission of power of 33 and 16 kilowatts respectively.

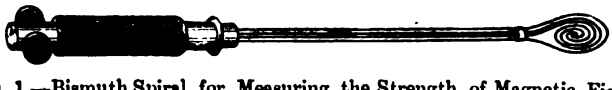

FIG. 1.—Bismuth Spiral for Measuring the Strength of Magnetic Fields. One-third actual size.

The exhibit of Messrs. HARTMANN and BRAUN is amongst the most forward. This firm has a large pavilion devoted solely to their use. Electrical measuring instruments are a speciality of Messrs. Hartmann and Braun, and they have numerous and important novelties in this department, of which only a few can be mentioned now. An instrument for measuring the intensity of a magnetic field is shown (Fig. 1), the principle of which rests on the alteration in resistance which a wire of bismuth undergoes when placed in a magnetic field. A thin insulated wire of this metal is wound bifilarly into a spiral, the ends being connected with the terminal screws of a vulcanite handle. The thickness of the spiral is only about 1mm. (·04in.), so that it can be inserted in very narrow spaces, as, for instance, the air-gaps of dynamos. The variation in the resistance is a measure of B, and 1,000 lines per square centimetre corresponds to a 5 per cent. variation; a more exact correspondence is to be seen from the gauge-curve of the instrument. Messrs. Hartmann and Braun have introduced a very practical improvement in the arrangement of the telescope and scale for mirror reading with the galvanometer. The telescope and scale are attached to an arm, which is movable, with a counterbalance round the instrument. By this means the instrument can be rapidly focussed and made ready for use; the telescope, as well as a small directing magnet, are removable at will. Amongst other new apparatus by this firm we may notice a Wheatstone bridge, for determining the resistance of conducting material in straight pieces, such as arc-lamp carbons, in which, by means of two consecutive observations, the contact resistance is eliminated. This instrument is adapted for small resistances, varying from 1 microhm to 5 ohms. Also a portable apparatus for the measurement of insulation, the instrument weighing about 30lb. This is a handy instrument, folding up into a small space, and capable of measuring resistances from 1,000 ohms to over 10 megohms. A second apparatus of this kind, with a battery, giving from 80 to 100 volts, and weighing about 44lb. altogether, measures up to 50 megohms. Two electricity meters are shown. The first consists of an ammeter (Fig. 2), in which the scale is exactly proportional to the current, the scale itself being usually left out; at fixed intervals the index of the ammeter is brought back to zero, and an ordinary registering apparatus is affected in proportion to the distance traversed by the index. This operation is done by an electro-magnet, which acts every minute in consequence of a contact made by a simple clock-work arrangement, and attracts an armature in connection with the axis of the pointer. The magnet acts for a few seconds, and is also used for the winding up of the clock-work, so that after the meter is set going no further attention is required. The coils of the electro-magnet have a high resistance, and take very little current. The meter is at present arranged for currents up to 50 amperes.

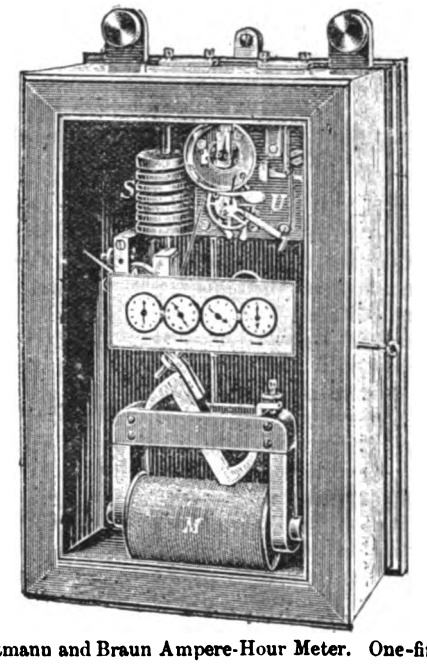

FIG. 2.—Hartmann and Braun Ampere-Hour Meter. One-fifth actual size.

The second instrument consists of a disc of copper, rotating between the poles of an electro-magnet, which is so arranged that the angular velocity of the disc is proportional to the strength of the current; the axis of the disc is attached to a registering apparatus, giving the ampere hours directly on the dials. This meter is made for currents from 50 to 1,000 amperes. Other new apparatus, of which detailed descriptions will be given later, include voltmeters giving signals by bells when the pressure is too high or too low; differential voltmeters, registering ammeters and voltmeters, and an electric pyrometer by Prof. Braun, reading directly up to 1,500° C.

In the Railway Apparatus Building the COMMITTEE OF THE PRUSSIAN STATE RAILWAYS exhibit their system of signals. The EASTERN TELEGRAPH COMPANY, in the Telegraphy and Telephony Hall, show Sir William Thomson's Siphon Recorder in its earliest and latest forms; Saunders' and Brown's self-acting Morse apparatus, requiring neither setting in motion nor winding up; relays and samples of cables. Messrs. Bullock and Brown's Unigraph is also on view. A loud-speaking telephone transmits music from Wiesbaden to the Hall, and the Munich and Frankfort operas can also be heard nightly, and the ubiquitous Phonograph forms one of the side-shows.

Later on electro-metallurgical processes will be exhibited in the Chemistry Hall, and a large proportion of the necessary apparatus is already *in situ*. Messrs. SIEMENS and HALSKE will undertake the electrolytic winning of copper directly from the ore and the production of ozone. This firm also supplies the electrical apparatus for the balloon (which has already made several ascents), such as a windlass driven electrically from the Machinery House in the Palm Gardens, a search light of 20,000 c.p. in the car, as well as telephonic apparatus.

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The area at the command of the Exhibition has been found much too small, and so a large space has been taken on the banks of the Main, where SIEMENS BROS., of London, have a fine display of apparatus for ship lighting, torpedoes, &c. In fact, this section of the Exhibition may be termed the Marine or Naval Section, as it is here that the electric launches are to be found, and a charging station has been erected. Another feature of the Exhibition is the almost universal use of compressed paper tubes for the electric light wires and cables. These tubes are, of course, very light indeed, and have been approved by the insurance companies' representatives. It is needless to say that the hammered metal work for which Germany is famous is everywhere in evidence, and a very fine effect is the result. Some samples of this ware have already become familiar in England, through the agency of Messrs. BEREND AND Co., but here it is seen in endless variety.

It is only natural that one should expect to find this Exhibition similar to the many others of the kind, but the Directors have made a departure in the right direction. They have been at work for the past eighteen months, and have from the first given the various firms who have agreed to exhibit an official intimation of exactly what, out of the list of manufactures submitted by the firms, they were prepared to admit. This has resulted in making the exhibits of a most varied description. Many firms here, as in England, make almost everything, but have only been allowed to exhibit such examples of their manufactures as a committee of technical experts have first of all approved. This system of selection is worthy of imitation outside Germany.

The Exhibition is by no means complete, and it will be quite the middle of June before everything is in full working order. The financial success of the Exhibition is, however, we are informed, beyond doubt, as it has been calculated that 600,000 payments for admission will ensure financial equilibrium, and of this number 400,000 are already assured.

EXPERIMENTS WITH ALTERNATING CURRENTS OF HIGH FREQUENCY.*

For the purpose of his experiments, Mr. Tesla employed an alternating machine with 400 poles, which, when run at full speed, permitted him to obtain 20,000 alternations per second. The current was first run through a condenser in order to avoid the possibility of injury to the machine.

Alluding to the electro-magnetic theory of light, and to the Hertz experiments and those of Dr. Lodge, and their application to the production of an efficient source of light, Mr. Tesla considered the electro-magnetic waves as unavailable for the production of luminous effects, for the reason that long before we could reach the necessary frequency the conductor would become opaque to the passage of the waves. Not so, however, with the electrostatic waves or thrusts. These, no matter what their frequency, can excite luminous radiation. He reasoned that the static effects in the Hertz and Lodge experiments were excessively small, due to the fact that they were produced in a practically closed coil, the spark acting as a bridge, making the coil practically continuous and depressing the potential. To obtain the desired difference of potential we must work with an open circuit generator of high potential, and of high frequency, to enhance the electrostatic effects, and it was the recognition of this fact which led Mr. Tesla to the results he showed.

Mr. Tesla then started a spark coil in action, the primary of which was in connection with his alternator, which was speeded to give from 10,000 to 11,000 alternations per second. As the discharges took place between the terminals of the coil, an exhausted Geissler tube held in proximity to the discharge did not light; but, upon blowing out the arc, the tube lighted up.

Mr. Tesla then showed the influence of insulated bodies having considerable size upon the spark length demonstrating the effect of capacity upon the nature of the discharge. He showed this by wrapping an insulated wire of about one foot in length about one terminal of the coil, and touching the other terminal with a brass sphere held in the hand; under these conditions streams of light emanated from all sides of the wire. When the sphere was removed, however, the streams disappeared almost entirely. He then cut off the wire in successive lengths, and the stream discharges became more marked and brilliant. Another experiment consisted in attaching two spheres of about four inches diameter to the terminals. The spark passes first between the two points nearest to each other on the spheres, then works up toward their tops, is extinguished and is re-established at the first point, this being continuously repeated. The neighbouring exhausted tubes and lamps were illuminated and extinguished in unison with the action of the spark between the spheres. Mr. Tesla then showed these static effects in a non-striking vacuum. A tube of this natures when connected to the machine, glowed brightly, and the terminal, became incandescent. Mr. Tesla then remarked that if, instead of using a filament in a lamp—which necessarily limited us in the degree of incandescence which we could practically employ—we could use solid blocks of carbon, much higher efficiency could be obtained. Based upon this reasoning, he has constructed a lamp, which he showed, containing two blocks of carbon in non-striking vacuum. When connecting these two carbons to the two terminals of the coil, or one to one terminal and the other to a body of some size, the blocks can be raised to high incandescence. This Mr. Tesla followed by demonstration of the phenomena with an unexhausted globe, and a single filament mounted therein.

In order to still further verify the conclusions that the electrostatic effects are alone active, Mr. Tesla placed a Geissler tube at right angles to the coil and at its centre. In this position the tube did not light up. When placed at the ends, however, the tube lit up brilliantly and gave sufficient light to read by.

He then showed how exhausted tubes could be made to glow in an electrostatic field. For this purpose two large sheets of zinc were connected to the terminals of the machine at a distance of about 15ft. apart. The tube when placed between these sheets glowed brilliantly, and could be moved about freely.

Coming to the physiological effects, Mr. Tesla adjusted the conditions, so that by touching one terminal with a brass sphere he raised the potential of the coil so enormously that a stream of light came out on the other terminal, and he estimated the difference of potential to be nearly 250,000 volts, and then performed the remarkable experiment of receiving the total discharge in his body, protecting his hands from burning by the brass balls held in his hands.

The lecturer then came to another class of experiments. He stated that he had used a system of conversion from high tension to low with the enormous frequencies of the condenser discharges. Mr. Tesla then showed an interesting experiment which consisted in passing the converted currents, produced in the manner just described, through a copper bar $\frac{3}{8}$ in. in diameter and bent into a loop. Ordinarily such a bar would constitute a short circuit, but Mr. Tesla succeeded in bringing lamps stretched across the parallel sides of the bar to incandescence, demonstrating that the impedance in the loop connecting the two sides was so great as to practically prevent the current from passing through it and hence acting upon the lamps in the manner described.

We have given but the merest outline of the many beautiful and highly suggestive experiments made by Mr. Tesla. Notwithstanding the fact that Mr. Tesla excited the intensest interest of his audience for three hours, he was nevertheless unable, for lack of time, to bring before them many experiments of even a more striking nature.

* Abstract of a report which appeared in the *Electrical Engineer*, of New York, of May 27th, of a lecture given by Mr. Nikola Tesla, on Wednesday, May 20th, before the American Institute of Electrical Engineers, at Columbia College.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

FRIDAY, June 5th.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "The Implications of Science." By Sr. GEORGE J. MIVART, M.D., F.R.S.

SATURDAY, June 6th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Scientific Study of Decorative Colour." By Prof. A. H. CHURCH, F.R.S.

FRIDAY, June 12th.

PHYSICAL SOCIETY OF LONDON.

5 p.m. Papers to be read: (1). "Ultimate Current and Potential Difference Analogies in the Methods of Measuring Power." By Prof. W. E. Ayrton and Dr. W. E. Sumpner. (2). "A Clock for Pointing out the Direction of the Earth's Orbital Motion in the Ether." By Prof. O. Lodge, F.R.S. (3). "Some Experiments with Leyden Jars." By Prof. O. Lodge, F.R.S. (4). "The Construction of Non-Inductive Resistances." By Prof. W. E. Ayrton, F.R.S., and T. Mather.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "The Rate of Explosion in Gases." By Prof. Harold Dixon, F.R.S.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

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ELECTRIC SUPPLY FROM CENTRAL STATIONS.

The subject of the distribution of electricity "by means of gas" is dealt with in some interesting notes by the *Journal of Gas Lighting*. Our contemporary is of opinion that this method should be seriously considered in connection with the municipal electric lighting of Glasgow, and in discussing the question alludes to some editorial notes in the concluding number of our last volume. We are said "to admit that where light is wanted on a tolerably large scale 'it is undoubtedly cheaper to put down the generating plant than to make use of the energy provided by the supply companies,'" and we are told that "this admission means nothing less than the total contradiction of the views expressed ten years ago with such confidence by the late Sir W. SIEMENS . . . . We were then told that nobody could expect cheap electric lighting until huge stations were established, supplying current generated by engines of the largest size and most economical type. Well," continues the *Journal of Gas Lighting*, "we have such generators in a dozen places, and yet *The Electrician* confesses that the little private stations in the City and West-End, where gas engines run the machinery, 'have no difficulty in generating a unit for 4d.'"

We feel tempted to go even further with the admissions and confessions to which our contemporary refers, but prefer at present to wait until the supply companies have shown us what they can do. We would point out that it is as yet by no means customary in central lighting stations to lay down "engines of the largest size," indeed it has only been done up to the present in one instance, and it is generally spoken of as a huge experiment—but this is a mere detail. We will, however, make one more concession which may please our contemporary, and that is, that the gas engine is a machine of such admirable economy compared with a steam engine,

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that if electricity is to be generated on a moderate scale there is no better means of doing it than "by means of gas," and there is, in our opinion, a great deal to be said for the method of distribution which it advocates so forcibly. The idea of sub-stations has a fascination for many electrical engineers, and where, as at Glasgow, the gasworks are in the hands of the municipality, if the gas mains are large enough, the sites easily obtainable, and if no trouble arose from noise and vibration, and—one more "if"—if the cost were really low enough, the advantages would be very considerable. Indeed, were it not for some of the figures given in Mr. CROMPTON's recent Paper, and the satisfactory way in which they were corroborated by Mr. WILLANS and others in the discussion, we should be inclined to "confess" that the economic results of the supply companies, as indicated by the price of the unit and by their balance-sheets, are rather discouraging. We allude here merely to the apparent cost of production and to the cost of distribution. It can be shown on paper that the engine-room expenses may vary from one penny to one halfpenny per unit, and that the total cost of production and distribution may be as low as twopence farthing, with an output of 800,000 units. In his Paper before the Institution of Civil Engineers, Mr. CROMPTON boldly gave the ideal figures of coal consumption at which he aimed, and as frankly confessed how far short he fell from them at present. Although no advocate of alternating currents has ventured to publish the coal consumption on the transformer system, it is generally admitted that they cannot yet compete with low-pressure supply in this respect, but no conclusion can be arrived at until the substation system of cutting out transformers has been thoroughly tried.

There are two chief points to be considered, production and distribution. Sir WILLIAM SIEMENS, rightly or wrongly, expressed the view that the larger the scale of operations the less would be the cost of electrical energy, and the fact that certain marked economies were observed as soon as the load was transferred from the Grosvenor Gallery to the generating plant at Deptford may be adduced in support of this view. But it must be remembered that we do not turn out electrical energy from a supply station in the same way that steel pens or woollen goods are produced in a factory. The reasons for the economy of production on a large scale in ordinary manufacture are sufficiently obvious, and consist largely in the saving of wages by specialisation or "division of labour," and by the mere extension of the use of machinery. But electrical supply companies, while they do on a large scale what many a householder does on a small scale, employ exactly the same methods, but with an enormous increase in labour. They employ large dynamos which are designed on very similar lines to the little machines, and they use accumulators of precisely the same kind. The economy of the large dynamo by reason of its higher efficiency is a mere trifle in the present comparison. The householder employs practically no labour. A domestic starts the engine and lets it run, and a mechanic looks in once a week at the most, to see that all is working smoothly. The householder has no costly mains, no wasteful transformers, no additional rent, and no staff of engineers, clerks, no directors and shareholders. No wonder then that he can compete with the supply company, and the only drawback is the trouble, and, in the case of anything but the very best machinery, the noise and vibration. One result, therefore, of the last breakdown at the Grosvenor Gallery was that several customers of the London Electric Supply Corporation put in their own machinery, for, after once having enjoyed the benefits of the electric light, no one will return to gas or oil if he can help it.

The economy of production on a large scale, then, is more than counterbalanced, as far as cost is concerned, by the expense of distribution and management. In all the balance-sheets which have hitherto been published, the item "labour" has mostly been charged to capital, since the supply companies are engaged in extending their works, and it is difficult to estimate the staff which will be required when they have settled down to a simple supply business. The two directions in which "distribution by gas" would save money, are first, in the coal consumption, and this, not only by the saving of so many tons of coal, used to get up steam, etc., and the theoretical losses of the steam engine, but in the utilisation of the numerous residues for which a good market has been created, and secondly, in the absence of trunk mains and feeders, since the existing gas mains, relieved to some extent from the demand for gas for illuminating, should without difficulty supply the gas engines for generating electrical energy. The enormous discrepancy between the 2½ lb. of coal at which Mr. CROMPTON aims, and the 10·7 per unit delivered, which he burns in practice, or even the 8·88 lb. per unit generated, to say nothing of the 17 lb. which the alternate current stations are said to use, is, we believe, largely due to waste in the boilers, and this partly because space is so valuable that really economical boilers are very rarely put down, and because they are used for so few hours during the day. No difficulty of this kind arises when gas engines are employed, and now that the makers are being induced to build engines of 200 H.P. a favourite size in supply stations, but too large for sub-stations, no difficulty need be apprehended as to the practicability of the system. But our contemporary talks as glibly of the Glasgow Corporation being "accommodated, at a reasonable rent, with a cellar into which they could put a couple of engines and the necessary electrical plant" as does Mr. GORDON whose requirements are far more moderate, but who is assured by his critics that cellars are not so easy to get.

The Glasgow Corporation have got into a sad muddle through making the mistake, in the first instance, of consulting a contractor as to what, in his opinion, would be the best system to adopt in Glasgow, instead of confining themselves to a request for estimates. The city authorities applied to the Local Board for permission to raise, for electric supply, the largest sum on record, and yet they have been unfortunate enough to confuse a contractor with a consulting engineer. Mr. CROMPTON has acknowledged that a length of 2,400 yards is his favourite maximum length of feeder, and it happens that the excellent sites at Partick and Dalmarnock are beyond this distance. It is only natural, therefore, that he should advise a central station. Had the Corporation consulted an alternating-current contractor of equal eminence, experience and success, if such an one there be, they would, of course, have met with so completely contradictory advice that they must have seen at once the folly of asking a contractor for anything more than an estimate. They have, however, sought counsel from scientific professors and from their own gas engineer, and have some half-dozen tenders; and, now, the *Journal of Gas Lighting* volunteers its advice on the subject. Electric light is no more likely to supersede gas than steam locomotion to supersede horses. As a matter of fact, the Midland and the London and North-Western Railway probably own more horses than were to be found in England at the time of the introduction of railways. It is possible, therefore, that after an equal lapse of time, if our contemporary has not changed its title to the *Journal of Gas Engineering*, it may still, in an indirect way, retain its present name through having encouraged the idea of distributing the electric light by means of gas.

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OBITUARY.

DAVID BROOKS.

We regret to have to record the death of Mr. David Brooks, who died at Philadelphia on Sunday last.

Mr. Brooks was born on January 26, 1820, at Brooks Vale, Conn. At the age of 20, David Brooks left college, and took a position of instructor of mathematics in the United States Navy. In 1845 he left the service, and engaged, with his friend, Henry O'Reilly, in the construction of telegraph lines. During that year he, in conjunction with James D. Reid, put in operation the first telegraph line in America, after the success of the original line between Baltimore and Washington had been established. This line was between Lancaster and Harrisburg. In the following year he constructed the line between Philadelphia and Pittsburg, a distance of 360 miles, crossing the Allegheny Mountains. In 1847 he constructed the first "repeater." This was used at Pittsburg and Philadelphia in the transmission of the speech of Henry Clay, on the Mexican War, at Lexington, Kentucky. The report of that speech was carried by express, which consisted of a relay of horses, to Cincinnati, and transmitted from Cincinnati to New York by telegraph, for the *New York Herald*, and was considered a remarkable feat in telegraphy. The arrangement of the repeaters, and Mr. Brooks' connection with the work, brought his name prominently before the telegraphing public.

In 1850 Mr. Brooks was appointed by the United States Court to give a written description of the Morse and Bain system of telegraphy, and in the voluminous report of the attendant trial his statements and opinions are repeatedly cited. In July, 1851, he sailed for Mexico, in the barque "Rosina," taking with him men, materials, and instruments for the construction of the first telegraph line in that country, between Vera Cruz and the City of Mexico. The work was accomplished during the ensuing six months. Upon Mr. Brooks' return from Mexico, in 1852, he was employed by the Pennsylvania Railroad Company in the construction and management of their telegraph lines between Philadelphia and Pittsburg. In 1854, Mr. Brooks was made superintendent and managing director of the Atlantic and Ohio telegraph lines. This company was absorbed by the Western Union in 1862, and Mr. Brooks remained with the latter company as district superintendent until 1867, when he resigned.

Of late years Mr. Brooks had identified himself with the use of oil insulation, and only a week or so since he was vigorously advocating its virtues in the American electrical journals. The first oil-insulated cable on the Brooks' system was laid in London in 1880. Paraffin oil was used, and considerable difficulty was experienced in keeping it in the pipes. Rosin oil was then substituted, and no further trouble was experienced from this cause. Since its first introduction oil has come into extensive use as an insulator, its latest application being to high-pressure transformers.

ELECTRIC AND MAGNETIC THEORIES.

BY SILVANUS P. THOMPSON, D.SC.

(*Continued from page 105.*)

§ 15. Energy being a quantity which can be definitely transferred from one part of space to another, and being capable of holding a definite existence in intermediate space when that space is occupied by a medium in a state of strain, there is nothing illogical or unphilosophical in the proposition that the energy-paths possess definite configurations, which can be investigated, and, in many cases, discovered. In the argument which follows nothing is taken for granted beyond matters involved in the usual definitions. If a unit of electricity is moved through an electric field from a point in space where the potential is high to a place where the potential is low, work is done by this unit in so passing; and if not spent in overcoming resisting forces *en route* may be utilised entire at the point of arrival. The energy which was potential at the first point may be in some other form on its arrival at the second point—the precise form of it is not now the question under discussion—that it has been transferred along a definite path there can be no manner of doubt. Nor need we actually suppose any electrified particle itself to travel along the energy path. Energy may be transmitted across a dielectric medium without any portion of that medium actually moving from one side of the space to the other. When heat is transmitted along a metal poker, or sound along a wire, no one supposes the metal particles to travel along the path of the heat or the sound. When light crosses from the sun to the earth, no one supposes that the hot solar atoms shoot across space. When sparks appear between the tips of the Hertzian exploring circuit, no one supposes these sparks to have been conducted across the medium from the oscillator; they have been set up as the result of energy which crossed the medium by invisible paths. If energy paths exist in the case of rapidly-varying currents, why not in the case of steadily-flowing currents; even though in the latter case we have no direct evidence to prove their existence?

§ 16. The medium surrounding a wire that is a part of an electric circuit is the seat of a double set of actions. Its electric potential varies from point to point, the medium being in a state of electrostatic disturbance. It is also in a state of maguetic disturbance, and its magnetic potential varies from point to point, but in a wholly different manner. For the sake

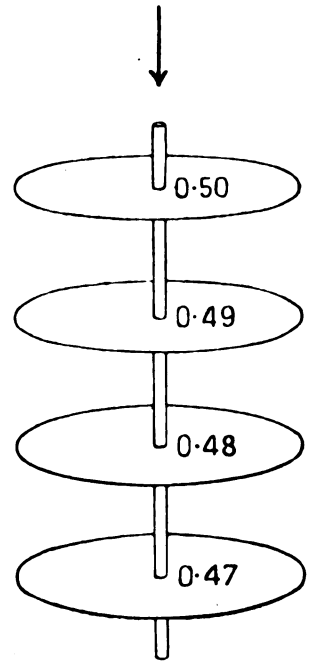

Fig. 12.

of simplicity let us consider an indefinite long straight wire, through which a "current" is passing. For the sake of numerical precision, suppose the wire to have a resistance of $\frac{1}{100}$ ohm per inch, and a current of 1 ampere to be passing through it. Then points distant an inch apart along the wire will differ by $\frac{1}{100}$ of a volt. Select one of these points where the potential has the value, say, of 0·50 volt. Through this point consider a plane drawn so that the wire is normal to it. All points in this plane will be at the same potential: the plane will be a surface of equipotential. No energy need be spent in moving a unit of electricity from any point in this plane to any other point in it. At other points along the wire let similar equipotential surfaces be drawn, as in Fig. 12. The lines of electrostatic force will be straight lines drawn parallel to the wire, and will cross the equipotential surfaces normally. But surrounding the wire will be another system of lines and surfaces, mapping out the magnetic properties. Consider any point P near the wire. On a unit magnetic pole, at a distance of r centimetres, the force due to the one-ampere current will be equal to $0{\cdot}2 \div r$ dynes, and will tend to move it (as viewed in Fig. 13) clock-wise around the wire. If we push it the opposite way around we shall do work upon the unit, and when we have pushed it once completely round the wire we

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shall have done $2\pi \times 0{\cdot}2$ ergs of work; or to move it through an angle of one radian ($= \frac{1}{2\pi}$ of a circumference) will require an expenditure of 0·2 ergs of energy. A plane drawn through P and the wire will be a plane in which all points are at the same magnetic potential. A system of such magnetic equipotential surfaces may be drawn around the wire; they will be set radially, at equal angles apart, reckoning from the zero position. For a current of 1 ampere the angle between

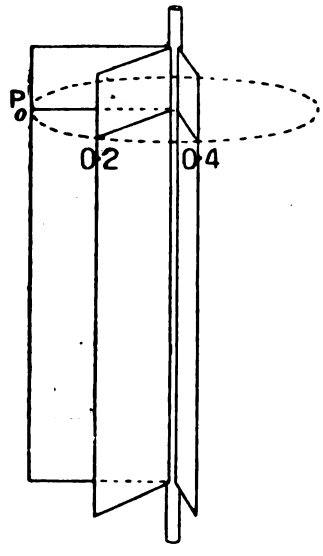

Fig. 13

surfaces that differ by $\frac{1}{10}$ of a unit of magnetic potential will be equal to $\frac{1}{4\pi}$. Now, imagine these two systems of surfaces to be superposed. The intersections of the electrostatic equipotential surfaces with the magnetic equipotential surfaces will be a set of radial *lines* (Fig. 14). Now consider what would happen if we had to move either a unit of electricity or a unit magnetic pole along one of these lines, such as P Q. Because the line is in a surface of electrostatic equipo

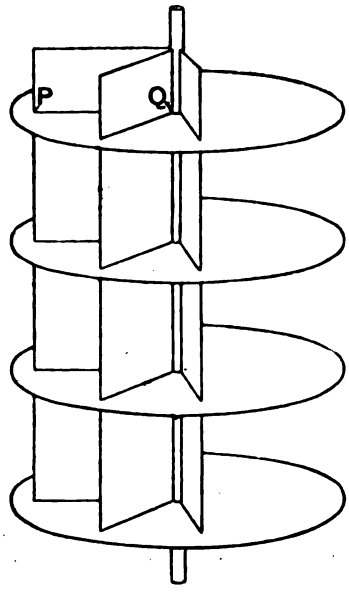

Fig. 14.

tential, no work would be done along the line in question in moving a unit of electricity along it; and because it lies in a surface of magnetic potential, no work would be done in moving a magnetic pole along it. Now, according to Poynting's view, it is precisely along such lines as these—the intersection of the static and magnetic equipotential surfaces—that the electro-magnetic energy flows. It is the only path compatible with the condition that the energy in crossing the medium shall not either add anything or take anything away from the energy already existing in the medium. If it were to leave this line, and pass either to a point of higher or lower potential in the medium, this would alter the state of the medium and change the configuration of the electrostatic and electro-magnetic stresses in it. That is, of course, exactly what happens during the time when an electric current is starting, during the variable period, while energy is being poured out into the medium to throw it into the peculiar state at the beginning. But we have been dealing here with the question of steady flow.

§ 17. Again, in the case of alternating currents setting up alternating electromotive forces across the medium in another circuit, during part of the oscillation some energy is being thrown outwards into the medium simply to set up stresses, and some more energy is actually crossing, by the paths so set up, into the second circuit; and during another part of the oscillation the energy that was momentarily resident in the medium is re entering the source to be again thrown out. Doubtless the energy paths are of somewhat complex form in all these cases; that is no reason why their real existence should be held doubtful. Take a single case. Consider a system of circuits with two interposed transformers; one transforming from a primary circuit into a secondary, the other transforming from the secondary circuit into a tertiary. How complex must be the paths here along which the energy flows, even if one confines one's attention solely to those parts of the circuits where the transformations are taking place! And yet one knows well that energy is being transferred, and that it must go along definite routes, and that these routes are not the copper wires, because here the great fact is that the energy is passing across, *viâ* the interposed magnetic medium, from one circuit to the other. The fact that the routes are complex does not prevent their being real. How complex, for example, are the paths by which the water in front of a ship streams round to the region behind it as the ship sails forward; yet no one doubts, because of their complexity, that such paths definitely exist.

(To be continued.)

ELECTRICAL INSTRUMENT MAKING FOR STUDENTS.

THE LINESMAN'S "DETECTOR."

In these occasional articles describing the design and construction of the apparatus commonly used by students and others, mere appearance will be ignored, and attention will principally be directed to efficiency and simplicity of construction. Although *mere* appearance will not be insisted upon, it must not be forgotten that neatness is everything in instrument making, as in most other handicrafts, and a little extra care and trouble bestowed upon an instrument often go a long way towards increasing its utility. It may be as well, therefore, to keep the following suggestions in mind, as they may save an appreciable amount of worry. Always keep your tools and implements sharp and in good condition. Never put anything away unless it is ready for use next time it is required. Do not mix nails, rosin, and silvered mirrors indiscriminately together; cardboard boxes are inexpensive, and it will save time and expletives to have a separate deposit for each class of article. Never consider a job done as long as you are capable of improving upon it.

The most generally useful and in fact indispensable of all electrical instruments, is the ordinary linesman's "detector," and as this instrument will be found useful in the construction of others, it will perhaps be as well to begin by describing a useful and easily constructed form.

Fig. 1 is a front elevation; Fig. 2 is a plan, the top being removed, and Fig. 3 a side elevation, the side being removed; *a a* is the outer case, 4in. × 4in. × 1¾in. outside measurements. This should be constructed of good close-grained wood, preferably mahogany, ¼in. thick; the top, bottom, and sides should be glued and fixed with brass screws, while the back (*a'*) should be merely screwed so that the inside of the instrument may be

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always get-at-able. It may be as well to mention in this connection that the use of iron nails and screws and of iron or steel generally should be avoided as much as possible in electrical instrument making, except, of course, where their magnetic properties render their employment advisable, as errors and mistakes may thereby be avoided. The glass front of the instrument *b* is about 3¾in. square by about $\frac{1}{16}$in. thick, and is let into a recess formed for it by cutting away the inside edges of the case to a depth of half the thickness of the wood (viz.,

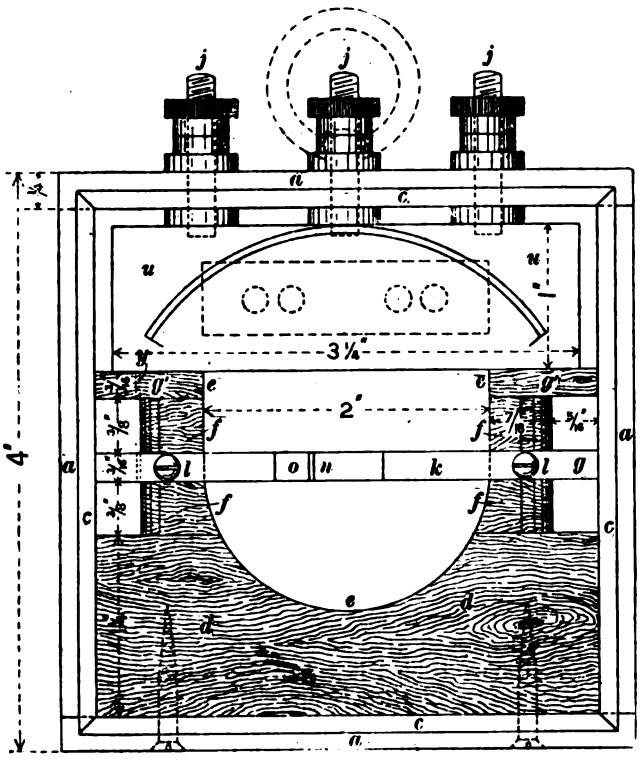

Fig. 1.—Front Elevation.

$\frac{1}{8}$in.), and a width of about $\frac{3}{16}$in. from the edge; these recesses must be neatly formed with the assistance of a tenon saw and chisel, their widths and depths having been carefully marked with a gauge. The glass is dropped into the recess so formed after the case is put together, and is fixed by filling in the angles, *c c*, with sealing-wax (preferably black); this should be neatly melted into the corners with a hot strip

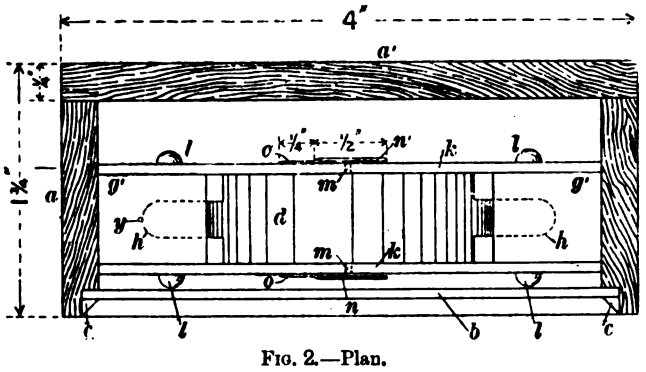

Fig. 2.—Plan.

of metal, and the superfluous sealing-wax removed from the glass with a little methylated spirit as soon as the cementing has hardened.

A piece of wood, *d*, 3½in. × 2⅜in. × $\frac{5}{8}$in., with the grain running longwise, has the semi-circular space, *e e*, cut away with a fret saw to receive the needle system; *f f* are recesses cut with a tenon saw and chisel. These should be $\frac{3}{8}$in. wide, $\frac{3}{16}$in. deep at the sides, $\frac{5}{16}$in. deep at the ends, and should be $\frac{7}{16}$in. apart, leaving a flange, *g*, between them and another flange *g'*, $\frac{3}{16}$in. thick at the top of the block, *d*; the corners of the grooves should be rounded off with a file, as shown at *h h* (Fig. 2); *i* (Fig. 3) is a drawer ring for carrying or suspending, which may be purchased at any ironmonger's; *j j* are terminals, and *k k* are brass strips for supporting the needle system; they are 3½in. long by $\frac{3}{16}$in. wide, by about $\frac{1}{16}$in. thick, fixed at the ends by screws, *l l*; these screws should be No. 3 round-headed brass screws, $\frac{3}{8}$in. long, and care must be taken in putting them in not to split the wood. The best way of preventing this is to drill holes in the wood to receive them, just sufficiently

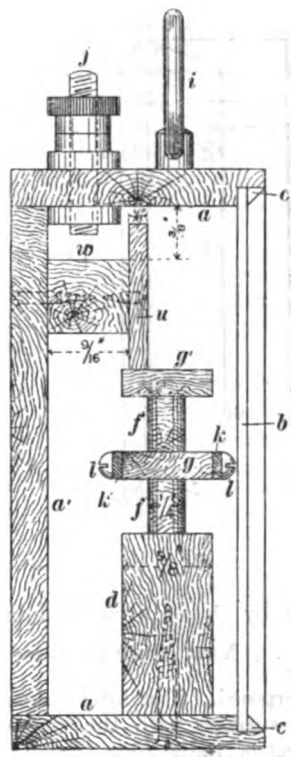

Fig. 3.—Side Elevation.

small for them to bite in. At the centres of these brass strips, *m m*, are two holes just large enough to receive a No. 6 needle without much side-play. *n n* are two strips of very thin brass, soldered at *o*. The use of these is described below.

Now as to the needle system. This is shown in elevation in Fig. 4, and in plan section in Fig. 5. *p* is a piece of brass rod $\frac{3}{16}$in. in diameter, and a little over ½in., say $\frac{9}{16}$in. long, with a hole drilled through it a shade nearer one end than the other, and of sufficient size to receive a bit of steel rod, *r*, 1⅞in. long by about $\frac{3}{32}$in. in diameter, which is to form the magnetic needle of the instrument. This piece of steel should be made dead hard, and cleaned; it should then be placed on a bit of

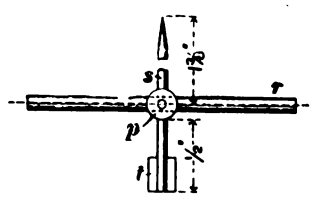

Fig. 4.
Needle System. Elevation.

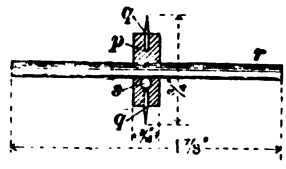

Fig. 5.
Needle System. Plan Section.

sheet brass, and held over a flame until it begins to turn a light straw colour, when it should be again chilled. The centre should be sufficiently cleaned to take solder. After having been magnetised as strongly as possible, the steel needle should be pushed through the hole drilled for it in *p* until it projects equally on either side (if the hole is too loose to hold it firmly, it should be slightly close by tapping the edges with the riveting side of a hammer). As soon as the needle is in its proper position it should be lightly soldered at each side of *p*, care being taken to make the soldering-bit thoroughly hot, in order

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that the solder may run before the heat reaches the ends of the needle. As each side is soldered, the whole should be dipped into water and cooled. Having fixed the needle, a hole should be drilled through p exactly at right angles to r, to receive the pointer s. The pivots $q\,q$ are the pointed ends of two No. 6 needles, cut off to the right length, and having their points slightly blunted. These are pushed into holes drilled for them in the exact centres of the ends of p. The best way to make these holes concentric and of the proper size is to drill p through from end to end with a No. 6 needle made into a drill. The pivots may be firmly fixed into the holes thus made for them by clamping p in a vice, and tapping the brass round them with a small cold chisel and hammer in such a manner as to close the holes round them. The distance between the points of the needles should be such that they do not touch both the stops $n\,n'$ at the same time; these stops are to prevent the ends of the brass piece p from rubbing against the brass strips $k\,k$. The pointer s is a piece of No. 16 hard brass wire about 1½in. long, pointed at one end, and screwed into the block p, and having a short piece of the same wire with a counter-balance of brass soldered to it, screwed into the block, on the under side. This counter-balance should be of just sufficient weight to bring the pointer well to zero after the instrument has been tilted.

The pointer must be fixed, and the needle system placed in position after the wire is wound in its grooves. This is effected in the following manner: Having given the block d a coating or two of shellac varnish, and having thoroughly dried it, proceed to construct a "former" of wood ¼in. thick, which must just fill up the space $e\,e$, and project a little above the flange g'; the surfaces of this former must be quite smooth, and it should be soaked for a few minutes in hot paraffin wax to prevent the wire from sticking to it. This former must be fixed in the space e in such a position that its sides are flush with the bottoms of the grooves $f\,f$. Now wind neatly and smoothly in each groove two layers of No. 16 B. W. G. double silk-covered copper wire. The outer end of the wire in the top groove should come through a hole in the flange g', shown at y, Fig. 2, and the wire should pass from the top groove to the bottom groove through a hole in g in a line with y. As soon as the wire has been wound on it should be varnished with shellac varnish, and covered with a layer of stiff note-paper, which must form a fresh surface for the fine wire coil which is next wound on. This should consist of No. 36 or 38 single silk-covered copper wire; the wire must be laid on as smoothly and evenly as possible, and each layer as it is finished must be varnished with thick shellac varnish. As soon as the grooves are quite full of wire the whole must be thoroughly dried, after which the "former" must be carefully extracted and the needle system fixed in position.

To perform this operation proceed as follows:—Screw on one of the brass strips k, and place one of the pivots in position in its pivot-hole m; next screw the counter-weight half-way through the hole made for it in p, and allow it to drop into the recess e. Then screw the pointer s into the other side of q with a pair of pliers, taking care neither to bend it nor to put any strain on to the pivot; the other brass strip may now be fixed in position, when the needle system should swing freely. The whole may then be fixed into the case as shown. The graduated scale of the instrument is drawn on smooth paper. A piece of cigar-box wood, u, 3¼in. by 1in., is fixed to a block of wood, w, screwed on to a', which must be of sufficient thickness to bring the scale close to the pointer. The scale should be held to u by means of drawing-pins until its proper position has been found, when it may be fastened with a little thin glue, and dried under a weight, care being taken that the scale is not shifted. The ends of the coils should be carried up the sides of the case and soldered to the terminals, connection being made as shown in the diagram, Fig. 6. It will be seen from this diagram that the thick wire coil is between terminals 1 and 3, and the fine wire coil between terminals 2 and 3; when terminals 1 and 2 are used the two coils are in series acting in the same direction. The case should be varnished both inside and out, and a coat of transparent varnish on the scale itself protects it from dirt, and renders it capable of being cleaned.

OPENING OF THE NOTTING HILL COMPANY'S CENTRAL STATION.

On Saturday afternoon last Prof. Crookes presided at the opening of the Central Station of the Notting Hill Electric Lighting Company, in Bulmer-place. Some hundreds of the Notting Hill residents and others were present at the ceremony.

The Notting Hill Company has adopted the three-wire system of distribution, the Crompton system of mains being employed, and at present about 3 miles of culvert, containing more than 40 tons of copper strip, have been laid. The Company was obliged, however, owing to cellars under the pavement, and not therefore having sufficient room, to revert to cables, and about 6 miles of cables in iron pipes have been put into the ground. With regard to the station, the Company has had the ground excavated for the boilers and engines, and the floor line is 22ft. below the street level. The dynamos stand on a concrete bed, and, to avoid vibration, this concrete bed has been isolated from all parts of the structure. The plant now put down consists of three Willans and Robinson engines, coupled direct to Crompton dynamos of the newest type; that is, two G.G. engines coupled to 50-kilowatt machines, having drum armatures, and one I.I. engine coupled to a four-pole dynamo, having a capacity of 120 kilowatts. There is room on the concrete bed for five more large sets. The boiler plant consists of two Babcock and Wilcox boilers, each of 350 H.P. capacity, and two semi-portable ones of the locomotive type of about 75 H.P. each, by Messrs. Marshall and Co. The Babcock and Wilcox boilers are fitted with purifiers, which receive the water from two Worthington pumps through a water heater. In the accumulator room there are two sets of Crompton-Howell batteries, each consisting of 56 cells of 61 plates, having a capacity of 500 ampere-hours. The switchboard controlling engines and dynamos was manufactured by Messrs. Crompton and Co., and is an exact counterpart of the one at the Kensington and Knightsbridge stations.

The number of lights applied for before the opening of the station was about 5,000. Of these, 2,500 have already been connected, and the remainder are being put on as fast as possible. When this station has its full complement of boilers, engines, and dynamos, it will be able to supply 25,000 lamps of 8 c.p., alight simultaneously, and, as all the lights connected are never alight at the same time, the station can deal with houses wired for 50,000 lamps.

It is the intention of the Notting Hill Company to immediately build another station for the southern portion of Notting Hill, and also a battery station for the portion of the district furthest from the present central station.

A detailed report of the opening proceedings will be found in a subsequent page.

ON SOME POINTS CONNECTED WITH MAINS FOR ELECTRIC LIGHTING.*

BY WILLIAM HENRY PREECE, F.R.S., PAST-PRESIDENT.

(Concluded from page 111.)

21. Such being the distribution of potential on a concentric main, and also on a system of two parallel conductors, it is now desirable to compare their relative security. We have to consider, not alone what happens when everything is in order, but what happens when accidents and faults arise. Nothing is perfect—we have only before us a choice of evils. Earth is the electrician's bane, but there may be circumstances under which it may become his antidote. No one but Mr. Ferranti has had the temerity to employ the earth as his antidote, and I must confess that I have been compelled to effect a compromise with him on the subject. His original form of cable was designed so as to place the outer tube completely to earth, but my own experiments† and his experience have shown that this outer tube must be thoroughly well insulated to prevent the introduction of serious disturbing effects on telegraphs and telephones. In Rome, where Siemens concentric cables are largely used, but without earth, the outer insulator was so frequently

* Paper read May 7, 1891, before the Institution of Electrical Engineers.

† "On the Disturbances arising from the Use of Earth for Electric Lighting Purposes," March 28, 1889.—*Journal*, Vol. XVIII., p. 314.

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pierced that Prof. Mengarini found it necessary to make the outer insulation thicker and better than the inner. The sudden stoppage of a flow of great energy from any cause must lead to effects analogous to those of momentum, and unless some buffer or cushion is provided, either in the form of a condenser or of the earth, a heaping up of pressure must occur somewhere, and sparking and rupture follow.

22. Mr. Ferranti claims for his concentric mains with the outer conductor earthed at one end, as shown by Fig. 11 :—

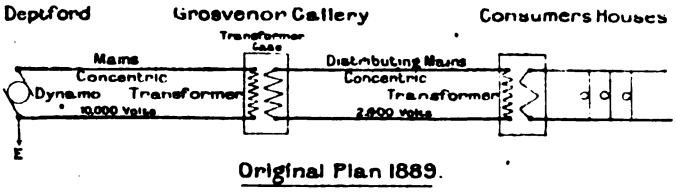
1. Absolute safety in handling by workmen, and freedom from fire risk.

2. Dispersal of the static charge accumulated on the conductors.

3. Freedom from disturbance on neighbouring wires.

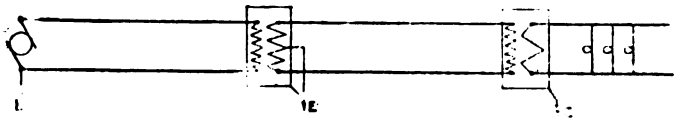
I can corroborate the last point. We in the Post Office are now quite unaware whether the Deptford mains are at work or not. It was not always so. At first, starting with imperfect cables, the disturbances were very serious.

The compromise effected between the Postmaster-General, the Board of Trade, and the London Electric Supply Corporation is shown by Figs. 12, 13, and 14, which also give some of the changes that have been made.



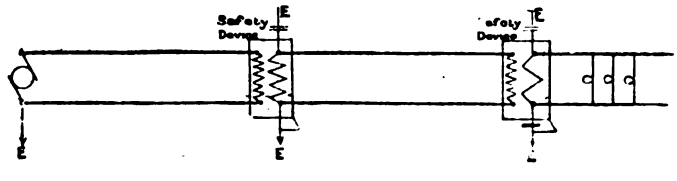
Original Plan 1889.

FIG. 12.



In use November 1890.

FIG. 13.



Authorised 1891

FIG. 14.

We allow earth on the outer conductor at Deptford, and at each distributing station, but not on mains other than concentric, or on the house service, excepting through a safety device.

With regard to high-pressure alternating-current systems generally, earth cannot be admitted on house wires, because with its use high insulation is imperative to reduce fire risks, and high insulation cannot always be maintained. Leakage means danger, in spite of fuses and safety devices. Fire and life risks are intensified by bad earths. Good earths are very difficult to secure, and alternate currents do not like earth—that is, the resistance of earth to alternate currents is much greater than that to direct currents.

We can secure safety in houses by—

1. Good materials.
2. Good workmanship.
3. High insulation.
4. Well-designed safety devices.
5. Frequent tests.
6. Incessant personal supervision.
7. NO EARTH.

In the wiring of houses supply companies and corporations cease to exercise responsibility. They deal with confiding customers, irresponsible contractors, untechnical and uneducated employés, and all sorts and conditions of men. Were it not for the Board of Trade to regulate our mains, and the Fire Insurance Companies to regulate our house wires, electric lighting in England would be as dangerous a pursuit as it appears to be in the United States.

23. The Board of Trade has forbidden the use of earth on separate conductors. This is absolutely necessary, for, except with concentric mains, the use of earth on one conductor might be exceedingly dangerous if the other conductor, by fault or otherwise, made earth. The inner conductor of a concentric main is so hermetically sealed, and so thoroughly protected by a succession of coatings, that it is well-nigh impossible for a leak to earth to be caused on it. Faults would take the form of a short-circuit, not of earth. A system to earth is one which has been placed at full cock ; a permanent fault has been put on intentionally. Equilibrium has been disturbed, and it is the security of the inner conductor of the concentric main that alone makes it acceptable.

24. The chief accident that one has to fear in the high-pressure alternate-current system is the piercing of the insulating medium between the primary and the secondary conductors of the transformer, and the formation of a contact between the two. Such a fault admits the high-pressure into the low-pressure system, and has been the source of nearly all the troubles that have arisen. Earthing the conductor puts a great strain on this medium. Risks of fire are increased. Additional preventive measures are necessary, and hence safety devices—the best at present in the market being Major Cardew's.

The use of safety devices which earth the conductor *at once* when the transformer is pierced, or when high pressure enters the low-pressure system, is, in my opinion, an absolutely necessary safeguard, and I never issue any specification without requiring Cardew's device, which is thoroughly effective and reliable.

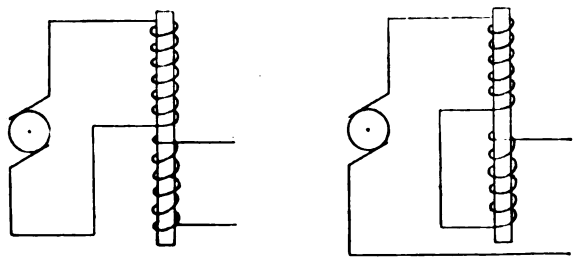
25. The use of low or of high pressure should not be a question of opinion or of objection. The supposed waste, danger, and difficulties of the one are disappearing under the able tuition of experience ; while the complicated regulation and variable distribution of the other are submitting to inventive skill. It is now a question of calculation and of finance. The only variable is the number of feeding points. The determining cause and the uncertain element is the density of lamps per acre or per mile of street. We start with this initial difficulty—that we do not know our customers, and we have to prepare for a visionary *clientèle*.

This Paper has been a little discursive. Its principal object is to direct attention to the simplicity of the two-wire parallel system of distribution, to the security of the concentric main, to the devices to promote the safety of the high-pressure system, and, above all, to the necessity for regarding the whole question from the engineering maintenance point of view rather than from that of the speculative promoter.

The following is the authorised abstract of the discussion which followed the reading of Dr. Fleming's Paper "On Some Effects of Alternating-Current Flow in Circuits having Capacity and Self-Induction."

DISCUSSION.—THURSDAY, MAY 14TH.

In opening the discussion, Mr. SWINBURNE said he was particularly interested in the subject dealt with in the Paper, for he considered it a most important one, and believed he himself was the first to suggest the true explanation of the phenomenon known as the Ferranti effect. When the effect was first observed it was looked upon as peculiar, and various authorities were exercised in finding an explanation. In December last, when he read a Paper on alternate current condensers before the Physical Society, no authoritative statement as to what actually occurred had been published, but he took the conditions and worked backward to see what the effect ought to be. He then found that putting a condenser on the



Elementary diagram of transformer, primary and secondary wound 1 to 1 ; and the same transformer with the coils connected in series, merely producing a "drop."

secondary mains would increase the pressure, and explained the rise by the action of the "leading" condenser current on the magnets of the alternator. Whether the rise might be said to be due to armature reactions or to self-induction was chiefly a question as to what was meant by self-induction. Several persons had attributed the "Ferranti effect" to the

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transformers, since the rise did not occur when the transformers were not interposed between the alternator and the trunk mains. This difference he showed to be caused by the condenser current in the alternator being four times greater when the transformers were on, and in addition the field magnets were only about one-fourth as strong, so that they were more easily influenced by the condenser current. He himself thought any rise due to the transformer would be small, but Dr. Fleming had found it fairly large. This was probably owing to the comparative smallness of the transformers used, for in very large transformers such as he assumed were employed the magnetic leakage to which he (Mr. Swinburne) attributed any rise caused by the transformer was relatively small. He ventured to think that Dr. Fleming had made a mistake in imagining the self-induction of the primary of a transformer an important factor in the phenomenon, for it could only act as a choking-coil in consequence of the magnetic leakage which existed. Part of the increased pressure was due to the "drop" in the transformer, and in designing transformers this drop should always be determined and allowed for. After giving a formula suppressing the drop in open circuit transformers, he said that Prof. Ayrton had found that there was a rise of pressure due to the transformer, and had also stated that a rise occurred in the mains themselves; this he (Mr. Swinburne) had shown to be impossible. He hoped Dr. Fleming would go into the subject of transformers more fully, taking the waste field into account. Unfortunately, this leakage was at present considerable, but he thought it would soon be reduced.

Prof. AYRTON said he took great interest in Dr. Fleming's Paper, because it confirmed many results brought forward by Dr. Sumpner and himself in a Paper recently read before the Physical Society. Referring to paragraph 6 of Dr. Fleming's Paper, he said that the general statements about Mr. Blakesley's conclusions and those of the author were rather confusing, for Mr. Blakesley's results were only applicable to shunted condensers, whereas those of Dr. Fleming referred to unshunted condensers. In treating of Resonance, the author, he said, concluded that there was only a narrow range of capacity within which the pressure at the condenser may be much greater than that at the machine. This conclusion resulted from his having chosen a coil having a resistance of only 10 ohms, and a very large self-induction of 200 secohms (henrys). As a matter of fact, resonance effects spread over a large range, and in practice it was impossible to get a coil with such a large time-constant as Dr. Fleming had imagined. The pressure at the condenser could, therefore, never be 100 or 1,000 times that at the alternator, 5 or 10 times being about the practical limit. The experiments made by Messrs. Siemens Brothers are very interesting, and distinctly proved that the ratio of transformation of a converter varied with capacity. No doubt Mr. Swinburne would say it was all due to leakage, but, nevertheless, the fact that the change existed was certain. In some experiments which Dr. Sumpner and himself had brought before the Physical Society a change of 11 per cent. was observed when the ratio of transformation was only 2, and it was then pointed out that with larger ratios the changes would be greater. In the case of the Siemens transformer the ratio increased 32 per cent. Referring to the mathematical equation No. 31 in the Paper, viz:

$$I = \frac{C\,p}{\sqrt{(1 - C\,L\,p^2)^2 + C^2\,R^2\,p^2}} V_0,$$

he said the matter was greatly simplified by dividing both numerator and denominator by $C\,p$, thereby obtaining

$$I = \frac{V_0}{\sqrt{\left(\frac{1}{C\,p} - L\,p\right)^2 + R^2}}.$$

The numerator then became an *electromotive force*, and the denominator represented *ohms*, for since R was resistance in ohms $\left(\frac{1}{C\,p} - L\,p\right)$ must also be of the order ohms, otherwise they could not be added together. On Slip 17 Dr. Fleming had written the equation in practically the same way, but did not prove the equation there given. The proof of (31) was greatly simplified by taking the current as the given element instead of the pressure. For, assuming that $i = I \sin p\,t$ where I is the maximum value of the current, then in a circuit having resistance R and inductance L, in series with a condenser of capacity C, the pressure between the ends at any instance was given by

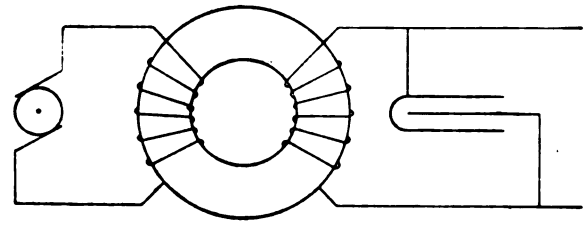
$$V = R\,i + L\frac{d\,i}{d\,t} + \frac{1}{C}\int i\,d\,t;$$

$$\therefore \quad = R\,I \sin p\,t + L\,p\,I \cos p\,t + \frac{1}{C}\int \sin p\,t\,d\,t;$$

$$\text{Hence } V = R\,I \sin p\,t + \left(L\,p - \frac{1}{C\,p}\right) I \cos p\,t.$$

The form of this expression showed that the phases of the two terms on the right hand side were in quadrature, hence the maximum values of V could be got by taking the square root of the sum of the squares of the coefficients, and equation 31 followed immediately. This method had also the advantage of introducing no differential equations of the second order, and was very convenient for teaching purposes. Referring to the so-called Ferranti effect, he inquired whether the pressure at the dynamo terminals was observed before the trunk mains were attached. He also took the opportunity of pointing out a mistake he had made in a diagram published in *The Electrician* on January 2, 1891. In this figure the connections were shown wrong, and hence gave the impression that a rise occurred in the part of the circuit representing the mains themselves. Although no rise had been observed, Mr. O. Heaviside had shown that under certain conditions such a rise would take place. He did not think Mr. Swinburne was correct in stating that he (Prof. Ayrton) had ever said there was a rise in the Deptford mains. What he did say was, that a voltmeter operated from the distributing mains at London read 100 volts, whilst a similar one actuated from the primary at Deptford read 80 volts; and this statement was now borne out by the figures published by Dr. Fleming.

Mr. EVERSHED thought neither Mr. Swinburne nor Prof. Ayrton had expressed the true feeling of the meeting towards Dr. Fleming for bringing forward such a valuable Paper. Although Mr. Swinburne had conceived the true explanation of why a rise of pressure should occur when the Ferranti trunk mains were connected to the transformers, he had not made himself clear, and his explanation was not complete, for the cause of the change in the ratio of transformation had not been given. The phenomena were, he thought, best considered separately. Taking the case of the general rise of pressure in both circuits by putting on a condenser, he pointed out that when the E.M.F. of the alternator was a maximum the condenser was fully charged, and no current passing into it, whereas the condenser current was a maximum when the E.M.F. was zero. Now, the E.M.F. of the alternator being zero when the armature coils are directly opposite the magnet poles, the condenser current attained its maximum at the instant when the coils were in a favourable position for influencing the fields. A little consideration, he said, showed that this current would strengthen the fields, and hence cause a greater E.M.F., and a rise would, therefore, be observed in both circuits.



To explain the change in the ratio of transformation he considered a 1 to 1 transformer having considerable magnetic leakage between the two coils. Just as was shown in the previous case, when a condenser was put across the secondary mains, the condenser current would be a maximum when the secondary E.M.F. was zero. But zero E.M.F. meant maximum induction in the iron, hence the condenser current being in step with the induction would increase the induction in the iron; but, owing to leakage, this increase would affect the E.M.F. of the secondary more than that of the primary, and hence change the ratio of transformation. It was, therefore, quite possible to neutralise the "drop" in transformers by putting on condensers, and had Mr. Ferranti designed his transformers to give a greater drop, he might have arranged so that when working on the trunk mains the "drop," instead of being converted into a rise, was exactly compensated. Referring to the method of writing equation (31) mentioned by Prof. Ayrton, he protested against the terms other than R being reckoned in ohms; for passing currents through ohms meant generation of heat, whereas no self-induction wasted energy. In his opinion the terms were of the nature of E.M.F., and ought to be called E.M.F.'s rather than resistances.

Prof. AYRTON asked Dr. Fleming to what cause he attributed the fact that the observed condenser currents given in Section 12 were considerably greater than those calculated. In some experiments made by Dr. Sumpner and himself on the same subject they had measured the current and calculated the capacity, and found the latter to agree very closely with that determined by ordinary ballistic methods.

Mr. SWINBURNE suggested that the increased capacity might be due to the "soaking in" which he had mentioned in his Paper on "Alternate Current Condensers," read before the Physical Society.

Mr. ADDENBROOKE said the soaking in of the charge might affect the capacity in a way similar to that in which the insulation resistance of a cable varied with the time the current was kept on. In giving the insulation resistance of any specimen it should be distinctly stated under what conditions the tests were made. Moreover, the resistance of a cable increased for a long time after it was manufactured, and almost any desired insulation resistance could be obtained by waiting long enough. In alternating current work the current was, he said, "on" for about $\frac{1}{100}$th of a second, and the resistance for such currents might be quite different to that found by steady-current tests. Information as to the properties of paper insulated cables, under various conditions, would be very valuable at the present time.

Mr. PREECE, replying to Prof. Ayrton's statement, that a coil having a time constant of 20 seconds could not be made, pointed out that Faraday's coil at the Royal Institution required two minutes for the current to attain its maximum value. A submarine cable when coiled in its tank had also an enormous self-induction, as was proved by a test made by Mr. Edison at the Telegraph Construction and Maintenance Company's Works, when he found that a telegraphic "dot" put in at one end of the cable came out 27in. long at the other.

Prof. AYRTON could not understand how self-induction could lengthen the dot, but capacity might do so.

THURSDAY, MAY 21ST.

Major CARDEW remarked that the condenser, on which the experiments mentioned in paragraph 12 of Dr. Fleming's Paper were made, had been constructed from imperfect plates, and since then a good condenser, kindly lent by Dr. Muirhead, had been carefully tested for capacity by the alternate current method. The capacity so found was in this case also greater than the capacity given by the makers. The discrepancy, he

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thought, might be due to the fact that Dr. Muirhead determines his capacities by rapid charges and discharges, which, in consequence of absorption, would give a result too low, whereas in the alternate current method the absorption would have the effect of increasing the apparent capacity. Experiments had also been made by the voltmeter method, described by Prof. Ayrton and Dr. Sumpner, and Mr. Swinburne, on the power spent in a one-microfarad condenser when subjected to alternating pressures of 650 volts. The power found was five watts, and after a long continued run the condenser was not much heated.

Dr. SUMPNER pointed out that many of the formulæ given by Dr. Fleming could not be used practically without considerable reservation as to the value to be substituted for R and L in the expressions. Those obtained by bridge tests and ballistic methods would (if used) lead to conclusions which were entirely disproved by experiment. Years ago Maxwell showed that the mutual induction of two coils produced a result similar to that brought about by increasing the resistance of the primary and diminishing its self-induction. Since secondary circuits exist in all electrical apparatus in the shape of iron, copper, &c., not infinitely laminated, the changes in the so-called "constants" of the primary coil may be very important. The ordinary formula for the angle of lag between the E.M.F. and current in a coil being $\cos\theta = \frac{\text{Resistance}}{\text{Impedance}} = R\frac{A}{V}$ where A is the current and V the volts, then, since the watts given to the primary of a transformer with open secondary are watts $= V A \cos\theta$, and this by substitution becomes $V A . R\frac{A}{V} = A^2 R$, the power spent in the transformer would come out to be that wasted in heating the primary coil, if the value of R taken be that obtained by bridge tests. This, of course, was a totally wrong result, because the effect of hysteresis and Foucault currents was to virtually increase the resistance of the primary circuit. The results of bridge tests could not, therefore, be used in the customary manner. To get correct results it was also necessary to determine L by alternate-current methods, but as nearly all these methods involved the assumption that impedance $= \sqrt{R^2 + p^2 L^2}$, if the wrong resistance be taken, the resulting value of L would be inaccurate. Considering the Ferranti 150 horse-power transformer, and assuming that its exciting current was 5 amperes, he pointed out that, according to ordinary methods of reckoning, $L p$ would be about 2,000. This, although it only gave a time constant of about a second, whilst in the coil chosen by Dr. Fleming $\frac{L}{R} = 20$ seconds, was, nevertheless, about 100 times greater than that required to produce a lag of 80°. If, however, the value of R be taken as determined by the power spent on open secondary circuit, the ratio of inductance to resistance would only be about one one-thousandth of that possessed by Dr. Fleming's coil. The author, he said, had made no reference to Mr. Swinburne's views on the Ferranti effect, nor to the results published in a Paper read by Prof. Ayrton and himself before the Physical Society. The experiments given in Table I. (section 17), did not show whether any of the rise occurred in the dynamo as well as in the transformer. The same theory accounted for rises in both parts; but as Mr. Swinburne had pointed out, the primary circuit of a transformer could not act like a coil with self-induction, unless there was some magnetic leakage. In the experiments made at the Central Institution, it was found that, under certain conditions, about half the rise was due to the self-induction of the transformer and the other half to the dynamo; the proportions differed, however, with the ratio of transformation.

Mr. BLAKESLEY said that for some time he had considered the measurement of self-induction by alternate current methods to be a dangerous operation, particularly when there was iron in the field, for in that case a coefficient was hardly conceivable. In 1886, he tested the coefficients of a Gaulard and Gibb's transformer, which, because the primary and secondary were similar, and similarly situated, ought to have had a ratio of 1:1, really gave a ratio of 3:2. Speaking of the rise of pressure produced by capacity, he pointed out that he published an account of such a rise long before the Deptford station was commenced, and he was not at all surprised when he heard that such a rise occurred there.

Mr. A. SIEMENS, referring to the curve given in Fig. 6, said that more recent experiments, using a different type of transformer, showed that the ratio of transformation was independent of the capacity.

Prof. AYRTON inquired what was the difference in the two kinds of transformers used, and

Mr. SIEMENS replied that one was an open-circuit and the other a closed-circuit transformer.

Mr. SWINBURNE directed attention to the practical points to be attended to in coupling alternators in parallel on mains having capacity. Another important point he had recently observed was that by employing a motor in conjunction with an alternator, the effect of capacity could be neutralised, for weakening the fields of the motor caused it to act like a self-induction. By strengthening the fields of a motor it could be made to act like a capacity. Hence, even in transmitting power over long distances by alternate currents, an attendant at the receiving end could maintain the pressure at that end constant independent of the load by simply varying the strength of the fields of a motor working on the circuit.

Dr. FLEMING, in his reply, thanked Dr. Sumpner for calling attention to the parts he had omitted from the Paper, and said that some practical method of getting the inductance of a transformer at any load was greatly needed. He, Dr. Fleming, had hitherto failed to get a clear idea as to what Mr. Swinburne's views really were, but he thought that both the orthodox theory and the armature reaction view would be found wanting in some respects. A significant fact, however, was that with large machines of small inductance no rise was observed; whereas, when small machines of comparatively large inductance were used the rise was great. In laying out future stations, it would be quite safe to use concentric cables where alternators of small inductance could be coupled direct on the mains. Whilst agreeing with Prof. Ayrton's remarks about the faulty wording in paragraph 6, and on the simplification of formulæ suggested, he thought that the criticism concerning the coil with a time constant of 20 seconds which he (Dr. Fleming) had chosen, was unnecessary, since Mr. Preece had given an instance of a coil which required two minutes for the current to reach its maximum; and Mr. Bate had called his attention to the fact that the field magnets of an Edison "Jumbo" machine required nine seconds for the current to attain its maximum. The construction of a coil such as he had imagined was thus only a question of cash and of space, and was not an impossibility. Speaking of the formulæ given in his Paper, he pointed out that good condensers could be looked upon as having negative inductance equal to $\frac{1}{C p^2}$ and impedance $\frac{1}{C p}$. For leaky condensers the inductance was given by $\frac{C}{k^2 + C^2 p^2}$ where k is the conductance of the condenser. The resistance of such a condenser to alternating currents was represented by $\frac{k}{k^2 + C^2 p^2}$, and its impedance by $\frac{1}{(k^2 + C^2 p^2)^{\frac{1}{2}}}$. The denominator of the latter expression had, he said, been called the *admittance* of the condenser by Mr. Heaviside, and just as *impedance* had now come into general use, so *admittance* would be found necessary when high frequencies become more common. Referring to Major Cardew's experiments on condensers, he thought that the observed effects might be due to leakage, for a leak would cause the capacity to appear greater when tested by alternating currents, and less when direct currents were employed. He could not agree with Mr. Evershed about the quantity of $L p$ being of the nature electromotive force, for although it was not of the nature of resistance in the sense of being dissipative, yet its dimensions were those of resistance, and only those of E.M.F. when multiplied by current. On the subject of throwing machines in parallel, he pointed out that the procedure depended entirely on the nature of the machines and of the circuit, for the operations necessary to put the large Deptford machines in parallel on the mains were the reverse of those required when the small machines were used. There was, he thought, still considerable room for investigation to separate the rise due to transformers from that due to armature reactions; one great difficulty was experienced in getting the resistances and inductances of the machines or transformers. Dr. Sumpner, he said, had greatly overestimated the magnetising current of the Deptford transformers, for instead of being 5 amperes it was, he thought, only ·4 ampere.

The following is the authorised abstract of the discussion which followed the reading of Mr. W. H. Preece's Paper on "Some Points connected with Mains for Electric Lighting," and of Mr. R. E. Crompton's Paper on "The Most Economical Mode of Feeding a Low-Pressure Network."

DISCUSSION.

THURSDAY, MAY 14TH. (AUTHORISED ABSTRACT.)

Mr. SWINBURNE remarked that in 1889 he had discussed the subject of disturbances in telephones with reference to concentric cables earthed at one end. Many persons thought no trouble would arise from such a course. This, he believed, was a mistake, for the outside conductor being near earth had a considerable capacity relative thereto. If a large current, say, of 250 amperes, was passing, the pressure between the two ends of the outer conductor would be about 210 volts, and this would cause a considerable earth current to surge backward and forward between London and Deptford. The effect of these currents had, he believed, not yet been observed, but it would become noticeable when the load got heavy. Mr. Preece, he said, thought earthing the secondary of a transformer tended to lead the current into temptation, but as a matter of fact the temptation was diminished by earthing the middle of the secondary. If this be done, neither secondary main could differ by more than 50 volts from the earth potential, whereas if one end be earthed, or neither, the risk and danger were considerably increased.

The further discussion was adjourned.

THURSDAY, MAY 21ST.

Mr. ADDENBROOKE said that the object of Mr. Preece's Paper was to point out the economy of the high-pressure principle, whilst that of Mr. Crompton's was to impugn that principle. On examining the question as to the cost of high-pressure mains, he found that to give a 10 per cent. loss in 2,400 yards of feeder supplying 100 kilowatts at 2,000 volts, would require a 7/14 cable, and this, of best Silvertown make, would cost about £165 per mile. This would give the cost of cable about £400 instead of £1,200, as stated in Table I. The cost of the culvert or pipe was taken the same for both the high and low pressure feeders. This, he thought, was unfair to the high-pressure system, and the cost of the transformers and apparatus was also too high. Altogether, the cost of the high-pressure feeder ought to be put at about half that of the low-pressure one under the conditions there stated. These conditions were, however, not practical ones, for no A. T. engineer would allow a drop of 10 per cent. in so short a feeder; 2½ per cent. would be much more reasonable. Taking this drop, the cost of the cables would come to about £1,300, but the 7½ per cent. saving would mean an increased revenue of about £160 per annum.

Mr. JACKSON described the method of laying underground concentric mains as carried out by the Newcastle-upon-Tyne Electric Supply Company, and exhibited samples of the work. The system, he said, was a draw in and draw out one, using cast iron pipes and concentric cables for 2,000 volts pressure. The joints were made in junction boxes by bolting copper rings cast to thimbles, in which the ends of the cables were insulated to the tops of porcelain insulators. The same points served also as

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connections for service lines, The advantages claimed were: simplicity and small cost, a six-mile circuit to feed 12,000 lamps with a variation of pressure never exceeding 6 per cent., having been laid at about £1,100 per mile. At the suggestion of the president Mr. Jackson promised to communicate further details in writing, for publication in the *Journal*.

Mr. KAPP said the case which Mr. Addenbrooke had made out for the A. T. system was not strong enough, for Mr. Crompton's calculations were vitiated by not taking the extra cost of plant into account. With a low-pressure feeder of 90 per cent. average efficiency about 30 per cent. more boiler, engine, and dynamo power would be required, as well as 30 per cent. more wages, &c., than for a high-pressure system. Mr. Crompton would thus have to lay down 30 per cent. more plant, and pay 30 per cent. more wages and interest for the privilege of using a low-pressure feeder.

Major-General WEBBER said Mr. Crompton wished them to believe that the A. T. people had now found that it would be necessary to use a low-pressure network, such as used in direct current distribution. This, he said, was by no means new, for Mr. Ferranti, as long ago as 1885, described a system like the one now mentioned by Mr. Crompton. Referring to Table II., he noticed that its author there admitted that 25 per cent. of the 2,400 yards of feeder would have to be laid in tubes. In practice, however, it was found that culverts could only be used for about a quarter of the total distance, and making this change would increase the cost of the low-pressure feeder by about £2,000; the interest would also be considerably augmented. Speaking of the 1 per cent. depreciation allowed on culverts and copper, as against 8 per cent. on cables, he said there was no admitted proof that the up-keep of one would be only one-eighth of the other. This point he (Major-Gen. Webber) had referred to in his Paper read last winter, but he was now sure that the figures 1 per cent. and 8 per cent. could not be admitted.

Sir W. THOMSON inquired what ratio the energy sold had to that generated in the various systems of distribution. In his opinion, the comparison would be favourable to the low-pressure system wherever it was practicable. In dealing with large conductors, both Mr. Preece and Mr. Crompton seemed to have ignored the fact that the conductivity was less for alternating currents than for direct ones. Conductors of 2 centimetres diameter offered 8 per cent. more resistance when the frequency was 80, whilst for 3 centimetres diameter the increase was 31 per cent. Mr. Preece's square inch section conductor would offer 25 per cent. more resistance to an alternating current of 80 periods per second, and at 100 periods the increase would be 30 per cent. As this was a matter of considerable importance in low-pressure networks he would suggest that all cables for currents greater than 200 amperes be made with jute instead of copper in the centre. On the whole, he thought it injudicious to rush to alternate currents for distribution purposes, and he himself rather inclined to continuous current distribution by feeders, as described by Edison. He was quite aware of the processes which had led to the A. T. system being usually preferred, and of the great advantages which in some cases could be realised by its use, but he believed that in future the direct system would predominate. The general idea in putting the generating station at a distance was to obtain cheaper coal, but he doubted whether more than 6d. per ton could be saved in this way. The possible use of condensation was another item, but so far as he was aware triple-expansion condensing engines had not come into use for lighting purposes. Rent of land was, however, an important consideration, as well as the necessity of diminishing vibration. Both these told in favour of the distant station, and, in his opinion, no other consideration ought to prevent engineers from putting their stations as near as possible to the consumers.

Mr. A. SIEMENS thought the principal object to be aimed at in designing stations was *simplicity*, and the design for a particular district must be guided largely by local circumstances. In his opinion the discussions on both Mr. Crompton's Papers had converged too much on high and low pressure. Speaking of cables he said that in addition to the theoretical conditions referred to by Sir W. Thomson, practical and financial points had also to be kept in view. In making concentric cables for the London Electric Supply Corporation, they had found that putting in a jute core increased the diameter of the cable, and added considerably to the cost. It was cheaper for them to put in extra copper to make up the conductivity. Referring to Mr. Crompton's estimate for the up-keep of mains, he concurred in Major-General Webber's protest against the 8 per cent. for insulated cables. As a matter of fact neither the cables put down in Berlin in 1881, or those in use at Bradford, had cost a farthing for up-keep since they were laid. In his opinion the up-keep of cables ought not to be put at a higher figure than that allowed for culverts.

Mr. SWINBURNE said the "skin effect" could be minimised, even in large conductors, by making them, say, in six smaller cables, stranded round an inactive centre.

Sir W. THOMSON pointed out that if each wire of such a cable was as much outside as any other wire, the full conductance would be obtained, but this condition was not fulfilled in cables as ordinarily constructed; and in conductors two or three centimetres in diameter, the conductivity for alternating currents is seriously diminished. With reference to the up keep of cables, he thought that, if properly constructed and laid, the up-keep should be practically *nil*.

Mr. A. E. MAYOR said that, by soaking the separate wires in an insulating medium before stranding, considerable resistance could be got between the strands; a light serving of cotton did not seriously increase the diameter of the cable. In this way he thought Mr. Preece's square inch section could be obtained without much diminution in conductivity for alternating currents. He characterised Mr. Crompton's estimate of £1,300 for 2,400 yards of concentric cable as absurd, and he assured Mr. Preece that great attention was being given to the construction of mains. He was also of opinion that rubber would be superseded by cheaper dielectrics. On the subject of feeding a network, he had no doubt but that high-pressure cables would be much cheaper than low-pressure ones.

Mr. PREECE, in reply to Sir W. Thomson, said that in one alternate current system with which he was acquainted the coal burnt per unit sold was 17lb., whilst per unit generated it was 8lb. In Rome, however, these numbers were 10lb. and 8½lb. respectively. This satisfactory result he attributed to the system of "banking" the transformers. Of direct current systems, he said that Mr. Crompton's statements were not corroborated by the Company's returns, for whilst he (Mr. Crompton) gave 7 to 8lb. as the consumption per unit generated, and 8 to 9lb. per unit sold, a Director informed him (Mr. Preece) that they did not get paid for two-thirds of what they generated. He hoped that before long it would be usual to get an indicated horse-power hour for 2 to 2½lb. of coal, and that 6 or 7lb. per unit sold would suffice. Referring to the square inch section of copper mentioned in his Paper, he said this was taken merely as an illustration. In practice, none of the mains need ever exceed a quarter of a square inch in area, and, as shown in his Paper before the British Association, the reduced conductance of such sizes for ordinary frequencies was not important. Sir W. Thomson, he remarked, had said a great deal in favour of low-pressure systems with numerous stations, but in so doing he had, apparently, overlooked the fact that working expenses were greatly increased by this duplication of stations. In designing the Bristol scheme, two stations were found to be much more expensive than one, and it was for this reason, and on account of its greater "simplicity," that the alternate current system with one station had been chosen. The three-wire system, he said, was not financially possible at distances greater than half a mile; while for five wires, the limiting distance was about a mile.

Mr. Crompton, not being present, did not reply.

A PHOTOGRAPHIC STUDY OF THE ELECTRIC ARC.*

BY EDWARD L. NICHOLS.

The arc lamp, fed by alternating currents, invariably hums and sings. The note, which is not to be mistaken for the hissing which we hear from continuous current lamps that are burning under improper conditions, possesses a definite pitch, determined by the rate of alternation of the dynamo. That the note is not due to the mechanism of the lamp itself is readily shown. The Jablochkoff candle, which is devoid of all mechanism, sings as merrily as the lamp with solenoid regulator; any form of hand-lamp will do the same. I do not remember having seen any definite statement concerning the source of this humming noise, nor any satisfactory discussion of the question. My attention was first brought to the very obvious explanation of the phenomenon by the study of certain curves of electromotive force, obtained by Messrs. Archbold and Teeple, in the course of an investigation of the alternating discharge between a ball and point. Shortly after this curve had been obtained, the curves of Messrs. Tobey and Walbridge, illustrating the performance of the Stanley arc lighting dynamo, appeared.

After studying these curves it seemed to me unquestionable that the humming of the alternating arc is due to the rapid periodic extinction and re-establishment of the discharge, the effect being similar to that observed in singing flames. When, some months later, opportunity was found of viewing the image of the arc of an alternating current lamp in the revolving mirror, I was prepared to witness the extinction of the arc during a definite part of each alternation. I do not know whether any member of the Institute has tried this simple experiment. I have seen no description of it anywhere, although Wiedemann mentions the application of the revolving mirror to the study of the continuous current arc†, and Joubert‡ (1880) makes brief mention of a very ingenious application of the plenakistiscope to the study of the changes to which the alternating arc is subject, during each period. When such a mirror, mounted upon a vertical axis, is set up at a convenient distance from the lamp, the images of the white-hot tips of the upper and lower carbons are drawn out by the revolution of the mirror into uniform, parallel bands, extending quite across the field of view. The intervening narrow strip, much darker, is the image of the arc itself. This region, however, is not uniform, It consists of alternate patches of purple and black, which mark the intervals during which the arc exists and is extinct.

Mr. McMynn's first step in the investigation which it is my purpose to discuss in this Paper, was to photograph the arc under conditions which would bring out this phenomenon. A camera with long bellows was set up near the lamp, the distances from plate to lens and from lens to lamp being such as to give a somewhat enlarged image of the arc. In the focal plane an opaque screen was mounted, which contained an opening just large enough to receive the image of the carbon points. The apparatus having been adjusted, a sensitive plate was driven past the aperture at high speed. The photographic image differed from that observed in the revolving mirror chiefly in the relative brightness of the arc

* Based upon experiments made by Mr. J. C. McMynn. Abstract of a Paper read at the general meeting of the American Institute of Electrical Engineers, New York, May 20, 1891.

† Wiedemann: *Elektricuat*, 4, p. 855.

‡ Joubert: *Journal de Physique*, Vol. IX., p. 300.

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proper, and of the incandescent carbon of the points. To the eye, the latter is the dominant feature; whereas the *actinic* image of the arc far exceeded in intensity that of the carbons.

These photographs establish the intermittent character of the alternating arc beyond question. They also exhibit in a new

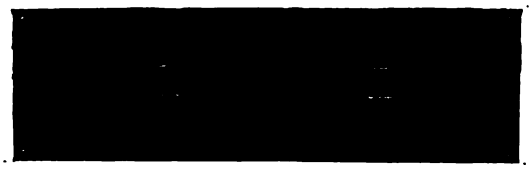

FIG. 1.—Alternating Arc. Long Arc (58 volts.) (Movement of Plate horizontal.)

light many interesting properties of the arc, some of which are already well known, while others have not been noted. Of the many negatives already obtained, a few characteristic forms are given in the accompanying plates.

FIG. 2.—Alternating Arc, showing oscillations due to Earth's field. (Movement of Plate vertical.)

Fig. 1 is an enlargement of one of the first negatives taken, with plates moving in a horizontal direction, at right angles with the axis of the carbons of the lamp. The speed of the plate was moderate, the size of the image smaller than the arc itself. The

FIG. 3.—Alternating Arc between Cylindrical Carbons. Arc viewed from West (Movement of Plate vertical.)

plate contains but little detail. The carbons do not appear at all in the photograph, which shows little besides the periodic interruption of the arc. In later negatives the size of the image was greatly increased and the plate was driven much more rapidly through the field. In many instances two or more successive exposures were made upon the same negative. Inspection shows that the greatest intensity resides neither in the arc itself nor on the incandescent carbons, but in the narrow region just at the ends of the arc. In this region, which, doubtless, is that where the so-called "contac-resistance" of the arc occurs, the illumination is sometimes intert mittent, as in Fig. 1; sometimes nearly uniform. The relative width of the intervals of darkness and of light is also seen to vary greatly under conditions not yet determined.

Figs. 2, 3, 4, and 5 were obtained by driving the plate vertically through the field, parallel to the carbons. An unlooked-for feature of all these plates was the oscillation of the arc from right to left in synchronism with the alternation period. Mr. McMynn suspected this vibration to be due to the action of the earth's magnetic field.* He was able to verify his view by comparing photographs made with the camera placed with its optical axis in the meridian with others in which the arc was viewed from the east or west. The disturbance was most marked in the former position and disappeared almost entirely from negatives taken in the latter. This point is well illustrated by Figs. 2 and 3, which show the image obtained from the north and from the east. The lamp in this case was supplied with cylindrical carbons. All the other photographs represent the arc between flat carbons. In a strong field, produced by placing the arc nearly between the poles of a horse-shoe magnet, the lines of force being

FIG. 4.—Alternating Arc, showing Oscillations in a stronger Field than in Fig. 2. (Movement of Plate vertical.)

perpendicular to the axis of the lamp and parallel to that of the camera, the vibratory effect was much increased (Figs. 4 and 5).

In this brief discussion I have left untouched many points which will suggest themselves to those who study Mr. McMynn's photographs. The interpretation of many of the features of these plates

FIG. 5.—Alternating Arc in a strong Magnetic Field. (Movement of Plate vertical.)

is at present rather obscure, but it is hoped that experiments now in progress will add something to our present knowledge of the phenomena connected with the alternating electric arc.

* It should be noted that Casselmann, as long ago as 1844, described the deflecting action of the earth's field upon the continuous current arc. (See *Poggendorff's Annalen*, 63, p. 588.)

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PHYSICAL SOCIETY.

At the meeting of this society, on May 22nd, Prof. PERRY, F.R.S., showed a new form of steam engine indicator (see Figs. 1 and 2.) A galvanometer mirror is fixed excentrically to a steel disc forming one side of a chamber communicating with the cylinder. The pressure of the steam bulges out the disc and causes the mirror to deflect a ray of light thrown on it in the ordinary way. A rotation at right angles to the former is imparted by the movement of the piston rod. The ray of light traces out the diagram on a screen suitably placed, and the complete figure is continuously visible owing to the persistence of impressions. This indicator possesses advantages over other forms, in being free from errors due to friction, or oscillations of the

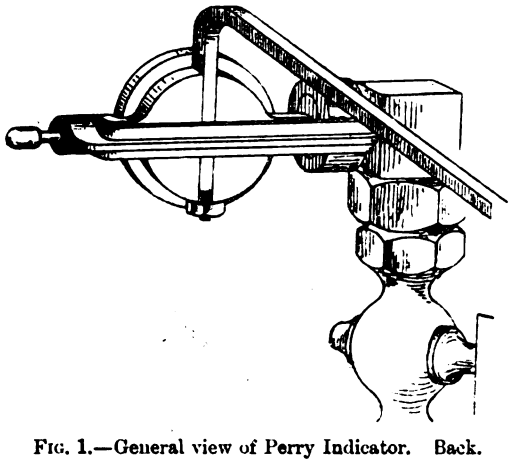

FIG. 1.—General view of Perry Indicator. Back.

springs and the alteration of their elasticity due to temperature changes. The errors of ordinary indicators are considerable at high speeds, owing to the ripples introduced into the indicator diagram. If the natural period of the spring is one-twentieth of the time of a revolution, the diagram is fairly free from ripples, but if it is as much as one-tenth no amount of friction in the indicator will prevent ripples forming. In the new indicator the

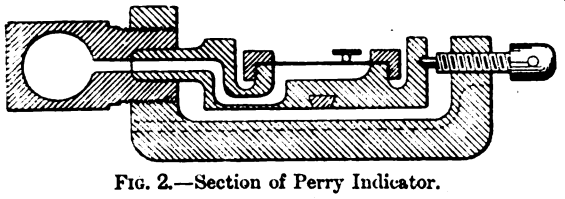

FIG. 2.—Section of Perry Indicator.

natural period of the disc can be made very short. The steel discs are easily movable, and can be proportioned to suit different pressures and speeds. For experimental and teaching purposes it is advantageous to see at once the alterations in the diagram caused by changes of load, pressure, &c. Several diagrams were exhibited to the meeting.

DISCUSSION.

In reply to Prof. Carus Wilson, Prof. PERRY stated that the deflection was proportional to the pressure in the cylinder within the limits for which any particular disc was intended.

Mr. ADDENBROOKE thought the instrument an important improvement on its predecessors, and considered it would prove of great service to electrical engineers.

Mr. SWINBURNE, said a peculiar merit of the indicator was that it could be permanently attached to an engine, like an ordinary pressure-gauge. He suggested the use of a small telescope instead of the ray method.

Prof. AYRTON thought that the instrument could be modified so as to be useful for analysing the shape of the curves representing alternating currents.

"Blakesley Method of Measuring Power in Transformers,"

BY PROF. PERRY, F.R.S.

This Paper referred to the supposed error in Mr. Blakesley's formula, due to the fact that transformers show magnetic leakage. The proofs of the formula hitherto given have been obtained by treating the equations in the manner first adopted by Dr. Hopkinson. On this system the reactions of the primary and secondary currents are represented by the equations

$$V = R_1 C_1 + P \frac{dN}{dt} \qquad 0 = R_2 C_2 + S \frac{dN}{dt},$$

where P and N are respectively the turns on the primary and secondary coils, and N is the magnetic flux between the coils. Here it is assumed that there is no magnetic leakage, and the author thinks that on this account the method is inferior to the original method of Maxwell, in which the induced electromotive forces are expressed in terms of co-efficients of self and mutual induction. On the assumption that there are no eddy currents Maxwell's equations are

$$V = R_1 C_1 + L_1 \dot{C}_1 + M \dot{C}_2 ; \qquad 0 = R_2 C_2 + M \dot{C}_1 + L_2 \dot{C}_2,$$

in which although L_1 M and L_2 may not be constant, it may be assumed that they are respectively proportional to P^2, PS, and S^2, if there is no magnetic leakage, and if the amount of magnetic leakage bears a constant proportion to the whole flux, the three quantities may still be assumed proportional to each other although M^2 is less than $L_1 L_2$. From these equations we obtain

$$V C = R_1 C_1^2 - R_2 \frac{M}{L_2} C_1 C_2 + \frac{L_1 L_2 - M}{L_2} C_1 \dot{C}_1.$$

Hopkinson puts down the last term as zero, but, owing to the very rapid rate at which C_1 changes, the last term is very important, even though M may be but a small percentage less than $\sqrt{L_1 L_2}$. On integrating this equation the first two terms on the right-hand side yield Blakesley's formula, and the last term vanishes in the integral because, however great the magnetic leakage may be,

$$\int C_1 \dot{C}_1 \, dt = 0,$$

when taken over a period, because the functions are periodic. Mr. Blakesley's formula thus appears to hold whatever the magnetic leakage. The Paper contains several tables of calculations showing the effect of magnetic leakage on the value of the terms in the equation.

DISCUSSION.

Mr. BLAKESLEY said he doubted the correctness of the assumption that the value of M was the same in the two equations, and thought that the result arrived at must be incorrect.

Dr. SUMPNER did not doubt that if the coefficients could be considered constant the formula was true, whatever the leakage ; but he did not consider that the action of transformers justified such an assumption. If the formula were true, it would also hold if there were eddy currents, as these would merely produce the effect of additional secondary coils. He had analysed Blakesley's method by using a modification of the Hopkinson equations, and had shown that the power, as estimated by Blakesley's formula, had to be lessened by the fraction represented by the expression—

$$X = \frac{\int x \dot{A}_p \int A_s \, dt \, dt}{\epsilon + \int A_p A_s \, dt},$$

Where A_p and A_s are the instantaneous values of the primary and secondary currents, and x is such that $N_p = N_s (1 + x)$ where N_p and N_s are the fluxes of magnetism at the same instant, through the primary and secondary coils respectively, and ϵ is a negligibly small quantity compared with the rest of the denominator. In obtaining this factor no assumptions whatever had been made, and it was easy to see that, if A_p and A_s could be assumed sine functions, and x a constant, the value of the factor X became x simply. In only one case did X reduce to zero, and that was when x was a sine function of the same period as A_p and A_s. He believed that in actual transformers x was approximately constant.

Mr. SWINBURNE pointed out that the split dynamometer was merely a wattmeter, and stated that he had transformers which, owing to magnetic leakage, would indicate an efficiency of over 100 per cent. if tested by Blakesley's method. If this method gives an efficiency of 95 per cent., and leakage causes a drop of 2 per cent. in E.M.F., the real efficiency is only about 94 per cent. He thought that the assumption that the currents followed a sine law was equivalent to supposing that there was no loss in hysteresis.

Prof. AYRTON said that no one would be more glad than himself to find that Mr. Blakesley's method was accurate, but he could not agree with Prof. Perry that Dr. Hopkinson was wrong in abandoning the academical method of Maxwell.

Prof. PERRY replied to the various points raised in the discussion. A paper on "Current and Potential Difference Analogies in the Methods of Measuring Power," by Prof. W. E. Ayrton and Dr. Sumpner, was postponed.

ON THE INFLUENCE OF TEMPERATURE AND MOLECULAR STATE ON THE BEHAVIOUR OF BISMUTH IN A MAGNETIC FIELD.*

BY P. DRUDE AND W. NERNST.

The two questions considered by the authors are the following : What is the influence of temperature on (1) the Hall effect in a bismuth disc ·5cm. thick by a magnetic field ; (2) on the increase (first observed by Righi) in the resistance of a bismuth rod traversed by an electric current in a magnetic field.

For solving the former question, plates of bismuth, one square and the other circular (the latter being placed in a glass vessel) were used. At points 90deg. apart on the circumference four

* *Wied. Ann.*, Vol. 42.

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platinum wires were fused in. The pair lying on one diameter carried the primary current, whilst the other two were connected to a galvanometer in order to show the Hall effect. The plates were enclosed in a narrow sheet iron box suspended between the poles of a powerful electro-magnet, and were heated with steam.

If e represents the E.M.F. of the Hall current referred to equal primary currents and taken as unity at the original temperature, with the square plate the following values were obtained :—

t	.....	20°	.....	254°	.....	23°	
e	.....	1·000	.....	0·418	.....	1·005	

and with the round plate melted into the glass vessel, the values :—

t	.....	14°	.....	243°	.....	100°	..... 14°
e	.....	1·00	.....	0·23	.....	1·23	..... 1·16

When the bismuth in the glass vessel was in the fluid state, the E.M.F. was 60 to 100 times less than when at the temperature of the room. The figures further show that the bismuth on cooling does not return entirely to its original state. In the interval between 243° and 310°, during which occurs the melting point of bismuth, the decrease in e extends considerably lower than is shown in the above values.

In order to decide the second question bismuth was melted in a thin capillary glass tube, and at each end two platinum wires were provided. One pair served to conduct the primary current, whilst the other led to a galvanometer. The deflection shown by the latter when the primary circuit was closed was, therefore, proportional to the resistance of the bismuth. The results obtained are given below, where r represents the resistancein Siemens units at a temperature t and δr, the increase in resistance due to the formation of the magnetic field at this temperature :—

t	r	δr	t	r	δr
16°	0·250	21·9 per cent.	290°	0·117	0·41 per cent.
100°	0·227	8 ,,	35°	0·207	15·1 ,,
223°	0·250	0·96 ,,	18°	0·208	18·6 ,,

The non-return on cooling to the original condition may be due to the bismuth having melted partly away from one of the platinum wires. In the neighbourhood of the melting point the influence of the magnetic field is clearly very slight, which corresponds to the results obtained on the first question.

The Hall phenomenon was also investigated with a plate of antimony, the influence of temperature being in this case much less noticeable. Mercury does not exhibit the Hall effect, but its resistance increases by about 0·2 per cent., when it is traversed by an electric current in a magnetic field.

PARLIAMENTARY INTELLIGENCE.

THE ELECTRIC LIGHT AT KILLARNEY.

Among the private bills which were down for consideration by the House of Commons on the 28th ult., was the Electric Lighting Provisional Order (No. 7) Bill, which came up for second reading, and which gave rise to some discussion.

On the motion that the Bill be read a second time,

Mr. ARTHUR O'CONNOR said he had been asked to oppose it on behalf of Mr. Sheehan, M.P., who was the Chairman of the Killarney Town Commissioners, and who was too ill to be present himself. He had, he said, no objection to the Bill so far as it related to the English towns included within its scope, but when it came to Killarney it was a different matter. All the other places were large and populous centres, whereas Killarney was not a town at all, but was a mere village. By the scheme which related to Killarney they were asked to give an important concession to a private individual, named Mr. Leahy, who was to enjoy the monopoly of supplying the electric light to this particular town for a period of 28 years. What he had to point out in connection with this matter was that Mr. Leahy was not a member of the Killarney community himself, but came from outside the district altogether. The Town Commissioners and the people of Killarney very properly contended that if they were to have the electric light the necessary powers should be placed in the hands of the Town Commissioners, who were the local authorities responsible for the government of the town. He might be told that the Town Commissioners had already held a meeting at which Mr. Leahy's scheme was fully considered, and that, after a careful consideration of the matter, the meeting sanctioned the scheme, which now came before the House with their approval. His reply to that was that the meeting in question was altogether irregular, that it was not properly constituted, and that, therefore, it had no power either to approve of or reject the scheme. He was informed that Mr. Jeremiah Sheehan, although he was the Chairman of the Town Commissioners, and although he was residing in Killarney at the time the meeting was held, received no intimation whatever that such a meeting was to take place ; and several other commissioners were in precisely the same position. It was on these grounds that he opposed the second reading of the Bill.

Sir MICHAEL HICKS-BEACH, on behalf of the Board of Trade, said that Killarney was not like an ordinary Irish agricultural town. It was a place which was much resorted to by visitors from all parts, and it had been deemed advisable to put forward a scheme for lighting it by the electric light. This scheme had been before the Town Commissioners, who had approved of it, and this was the first he had heard of any supposed irregularity in the calling of that meeting. The application for powers to supply the electric light was opposed by Lord Kenmare and certain other persons who were lessees of the Gas Company ; and, with all respect to the hon. gentleman who had raised this question, he must say that he thought the real opposition to the Provisional Order came, not from the inhabitants of Killarney, but from the Gas Company. The Town Commissioners originally intended to apply for a Provisional Order ; but, having further considered the subject, they withdrew their application and entered into an agreement with Mr. Leahy that he should pay them the expenses which they had incurred, and that they would then assent to his obtaining a Provisional Order, with certain amendments, reducing the maximum price of the electric light, and the number of years during which Mr. Leahy was to have the monopoly. The terms agreed upon were distinctly favourable to the Commissioners. So far from there being any general objection on the part of the residents of Killarney, there had been no petition against the scheme since the arrangement he had indicated was entered into. Under these circumstances he asked the House to read the Bill a second time, and then, if any further inquiry was deemed advisable, he should not have the smallest objection to referring so much of the Bill as related to the Killarney scheme to a Select Committee,

Mr. O'CONNOR was afraid any inquiry before a Select Committee would result in a heavy expenditure, so that the offer was scarcely one that he could accept. Would the right hon. gentleman allow the matter to stand over, to enable communication to be made with the Board of Trade from Killarney ?

Sir M. HICKS-BEACH did not see what could be gained by such a course. If the Bill was read a second time now there would be ample time to make any necessary inquiries before the further stages of the Bill were taken.

The Bill was then read a second time.

LEGAL INTELLIGENCE.

Hampton and Sons v. The London Electric Supply Corporation.

In the Queen's Bench Division of the High Court of Justice, on Thursday last week, the case of Hampton and Sons *v.* London Electric Supply Corporation (Limited) came before the Lord Chief Justice of England and a special jury. This was an action brought by the plaintiffs, upholsterers, &c., carrying on business in Pall Mall East, against defendants to recover £3,000 damages in respect of an alleged breach of contract. The defendants denied that there was any contract between them and the plaintiffs. Mr. Jelf, Q.C., and Mr. Lee Roberts appeared for the plaintiffs, while Mr. Moulton, Q.C., and Mr. Pyke represented the defendants.

Mr. JELF, in opening the case for the plaintiffs, said that in 1888 they extended their premises by erecting new buildings. They were anxious to have their premises fitted with the electric light, and they accordingly put themselves into communication with the defendants, with the result that the defendants agreed to give them a continuous and regular supply of electric current to the extent of 600 lights. In order to make their premises suitable for an installation, the plaintiffs expended considerable sums of money. Originally it was arranged that the plaintiffs should have the supply by October 1, 1888, but the period for carrying out the necessary works was extended by mutual consent to November 27th. The defendants, however, failed to give the plaintiffs the supply of electric current, and the result was that they sustained a considerable loss. The defendants had agreed to supply the plaintiffs with the current at 12s. per light per annum, but in consequence of the breach of contract the plaintiffs had to obtain a supply of electric current from another company, at a charge of 25s. per light. The plaintiffs were without electric light from November until March, and in order to light up their new premises they had to use oil lamps, which seriously affected their trade. He (the learned counsel) submitted that there had been a clear breach of contract, and that the plaintiffs were entitled to substantial damages.

Mr. HAMPTON, one of the plaintiffs, was called, and bore out the opening statement of counsel. He added that the failure of the defendants to supply his firm's premises with the electric current had a serious effect upon their business. The takings of the firm from December, 1887, to March, 1888, inclusive, amounted to £55,998, but during the same period of the following year they fell to £36,041.

Mr. CLAREMONT, formerly engineer in the employment of the defendants, Mr. J. E. GORDON, of the Metropolitan Electric Supply Company (Limited), and Mr. R. S. ERSKINE, of the Kensington and Knightsbridge Electric Lighting Company, also gave evidence in support of the plaintiffs' case. In cross-examination, Mr. Gordon admitted that 25s. per lamp per year was a fair price.

Mr. MOULTON, in opening the case for the defendants, contended that the correspondence between the plaintiffs and his clients did not amount to a contract. The defendants offered to supply the plaintiffs with the electric current at the rate of 7½d. per unit, and they had always considered that such an offer was determinable by the customer simply giving notice that he desired to discontinue the supply. The customer was not compelled to use the current ; it was connected to his premises, and if he used it he was charged according to what he used. That being so, it was absurd for the plaintiffs to contend that the defendants were liable for every conceivable item of damage which might arise from an accident to the supply. In the winter of 1888 there was a long period of fog and darkness, and consequently there was a great strain upon the defendants'

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plant. Unfortunately this strain ended in the breakdown of their principal machine. The defendants had to restrict the supply of electric current to their customers and to decline to accept any new applicants. They were also compelled to withdraw the offer to supply the plaintiffs with the electric light. Instead of being in a position to take the electric current in November, 1888, the plaintiffs' new buildings were not properly fitted until February 15th, and they had a supply of electric current by March 11th. The defendants, while denying liability, had paid £75 into Court to meet any damage which the plaintiffs might have sustained.

Mr. CUNDELL, electrical engineer, stated that he was employed by the plaintiffs to superintend the fitting up of their premises for the electric light. Messrs. Crompton and Co. fixed the necessary wires, &c. The whole of the work was not completed until February, 1889.

Mr. WILSON, an electrical engineer, formerly in the employ of the defendants, and Mr. R. S. BAIN, chief accountant to the defendants, also gave evidence in support of defendants' case.

The learned counsel having addressed the jury on behalf of their respective clients,

His LORDSHIP summed up the whole case, and asked the jury whether there was any document in the case which could be called a contract, and, if so, whether it had been broken. In the event of their answering these questions in the affirmative, they would also have to say what damages the plaintiffs had sustained. He reserved to himself the power of subsequently determining whether there was a contract in point of law.

The jury found that there was a contract in the terms of the form of application, and that there had been a breach, and they assessed the damages at £250.

Mr. Lee Roberts on Friday morning applied to his Lordship to enter judgment for the plaintiffs in accordance with the findings of the jury.

The LORD CHIEF JUSTICE said he was unable to do so, as he could not see any evidence of a contract. Judgment would therefore be entered for the defendants with costs. A stay of execution would be granted with a view to an appeal.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *May* 16, 1891.

The Portelectric System.—The New England Portelectric Company has just issued its annual report. The Portelectric system depends for its motive power on the attraction of solenoids distributed along the track for a cigar-shaped iron car. It is intended principally for automatically carrying mail and express matter at high speed over considerable distances. Prof. A. E. Dolbear is the electrician of the Company, and in addition the system has been thoroughly examined by Mr. F. L. Pope, a well-known electrical engineer in New York. An experimental track, oval in shape, and about 2,800ft. in total length, was laid out. The grades and curves were somewhat severe, and hindered thoroughly successful experiments. At the time of Mr. Pope's inspection the maximum speed attainable with the apparatus, as then arranged, was less than 35 miles an hour, but he expressed the opinion that this figure can be very much increased by using a better track, perhaps even rising so high as 150 miles an hour, although this latter figure seems purely hypothetical. The amount of wire required for solenoids per mile is nearly 20,000lbs., and in most of the experiments the flashing at the switches of each solenoid was most formidable. The passage of the car has been described by some observers as resembling more than anything else the fiery train of a rocket. Mr. Pope's suggestion for remedying this is the momentary short circuiting of each coil, and, although this would at the same time short-circuit the dynamo, it is perhaps the best way out of the difficulty. Altogether the results thus far obtained have not been particularly flattering to the system.

May 23, 1891.

Annual Meeting of the American Institute of Electrical Engineers.—With every year the annual meeting of the representative electrical organisation of this country grows in interest and importance. Last May the experiment was tried, for the first time, of holding it outside of New York City, and the Boston meeting will long be remembered by those who had the good fortune to attend it. This year the meeting was held as usual at the headquarters of the Institute, No. 12, West Thirty-first-street, New York, and was an unqualified success both as regards attendance and the character of the Papers presented. On Tuesday evening, May 19th, the opening meeting of the session was held, and was confined strictly to elections and business matters. Alexander Graham Bell was elected president for the ensuing year in place of Prof. William A. Anthony, whose term expired. This selection of the presiding officer met with the most cordial approval of the members. The vice-presidents elected were Mr. T. D. Lockwood, well known from his long and intimate connection with the telephone interests; Mr. O. T. Crosby, head of the railway department of the Thomson-Houston Company; Mr. Carl Hering, and Mr. W. J. Hammer. After the election of officers the formal reports of the secretary and treasurer were laid before the meeting and accepted, and a small amount of routine business was transacted; and an adjournment was then taken until Wednesday morning, when the first of the regular sessions should begin.

It was 10 o'clock the next morning when the electricians began to assemble around the headquarters, and 125 names were soon upon the records, more than 100 of them being members of the Institute. A little before 11 o'clock the meeting was called to order, and the first Paper was the interesting account of a stationary motor design by Prof. F. B. Crocker. This was a very neat and finished exposition of the principles of motor construction, especially as exemplified by the admirable series of machines designed by the author and his colleague, Dr. S. S. Wheeler. As might have been anticipated, the discussion brought out very many points of interest. The designing of the motor, apart from the dynamo, is a subject that has not been very freely treated in electrical literature, and consequently a number of the gentlemen present drew upon the stores of their practical experience for the edification of their fellow members. In fact, so instructive was the discussion that it prolonged itself until nearly one o'clock, when the other Paper put down for the morning was transferred to the afternoon. In the afternoon the first Paper brought up was Prof. E. L. Nichols's description of a very instructive series of experiments on the electric arc carried on by means of photography. After a brief discussion, in which Prof. Elihu Thomson was the principal speaker, Mr. Carl Hering read a Paper on a graphical method of calculating wiring that, like the previous Paper, led to a discussion of more interest than length, and in which Dr. F. A. C. Perrine showed another beautiful graphical method for accomplishing the same end. Dr. Perrine then went on to read a very clever and exhaustive account of the practical phases of electrical welding, as it had been tested in the great Roebling Factory, of which the author was the electrician. This Paper occasioned a somewhat lengthy discussion, in which Prof. Thomson took a prominent part, giving some interesting results of his own experience and a description of recent methods. Mr. F. J. Sprague's Paper on the rapid transit problem in New York was postponed until the morning. The evening session of Wednesday was a unique experimental lecture by Mr. Nikola Tesla, giving a series of the remarkably beautiful experiments with alternating currents of high frequency which he has carried on during the past year. Some account of this remarkable work was recently given in the *Electrical World*,* and the experiments shown were in part those described in that preliminary Paper. Mr. Tesla opened his lecture with a very suggestive general discussion of some of the phases of electrical theory that had led him into this particular field of research. The characteristic of the forces which he had turned to account in his investigations was the frequency of alternations enormously greater than had ever hitherto been used. Twenty thousand per second was reached during some portions of the experiments. Some very striking effects of high frequency sparks from induction coils were shown, magnificent brush discharges, the effect of adding capacity to the circuit, and of the increasing density at one of the electrodes. The most striking results, however, were the brilliant illumination of incandescent lamps and Geissler tubes at considerable distances from the induction coils, and the very extraordinary transference of energy through the glass walls of an incandescent lamp at short distances. These high frequency discharges from an inductorium do not pierce a dielectric in the ordinary sense of the word, but seem to stream through it even more freely than through the air. The attendance at this lecture was very large, and Mr. Tesla

* Reprinted in abstract in *The Electrician* of March 6, 1891, Vol. XXVI.

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held his audience as it were spell-bound from half-past eight until nearly midnight.

Thursday morning Mr. F. J. Sprague's Paper on rapid transit in New York was read, and proved to be a most masterly discussion of the present situation and some of the general possibilities in the way of rapid transit. No attempt was made to describe any particular ideal equipment. During the discussion an exceedingly interesting brief address was made by Prof. George Forbes, giving some account of the success that has been attained in the City and South London Railway. Before the formal meeting the members of the Institute had spent some time in going through the Crocker-Wheeler motor factory, which was thrown open for their inspection, and the hour for adjournment arrived before any further Papers had been read. Early in the afternoon the remaining Papers were taken up. These included the description of a new device for measuring alternating-current potential, by Mr. Geo. S. Moler; the study of the variation of electromotive force in arc light dynamos, by Mr. M. E. Thompson, of Cornell University; and finally a group of three Papers that provoked most animated and vigorous discussion. One of these was by Mr. G. W. Walker, of New York, on electric meters. Mr. Walker is the inventor of a very beautiful and accurate photographic meter, and took up the cudgels for photographic and other integrating meters as against the mechanically registering type. His remarks on the Thomson wattmeter were somewhat severe, as he called special attention to the fondness of that instrument for continuing its rotations in one direction or the other when no electricity is being consumed, a phenomenon due to a stray field from the coils that are always left in circuit. Prof. Elihu Thomson and Mr. Edward Weston took an active part in the discussion at once, and some exceedingly instructive and edifying suggestions were the outcome of the triangular duel that ensued. Then came Dr. W. H. Wahl's discussion of the aluminium problem, which was calculated to arouse the advocates of electrical processes for extracting this metal, inasmuch as the author championed the purely chemical methods. The aluminium men were out in force, and comments were, to say the least, active. The concluding Paper of the session was read by Mr. Oberlin Smith, who endeavoured to persuade the assembly that aluminium should be called "alium" in the interest of those who are too lazy to speak five syllables. The suggestion was met with, perhaps, the most vigorous disapprobation ever visited on a Paper before the American Institution of Electrical Engineers, and it is not at all likely that the topic will be discussed further.

In the evening the Electric Club extended the privileges of the club house to the engineers, and a very pleasant reception occupied the evening. The entertainment committee of the Electric Club arranged for a loan exhibition of early electrical books, apparatus and models, of special and unusual interest, including some very rare specimens both of electrical literature and electrical apparatus. With this reception closed what on the whole, may be said to be the most successful meeting the Institute has ever enjoyed.

PARIS NOTES.

(FROM OUR OWN CORRESPONDENT.)

PARIS, *June* 2, 1891.

The electricity meter competition organised by the Paris Municipality terminated on Saturday last by the publication of the prize list. The Aron and Thomson-Houston meters have obtained the two first prizes of 5,000fr. each; these instruments, available alike for continuous and alternating current circuits, having been deemed by the Comtmittee of Experts to fulfil all the conditions laid down. M. Frager has obtained two prizes of 1,000fr., one for his continuous-current and one for his alternate-current meter; while M. Marès' ingenious continuous current meter has also been awarded a prize of 1,000fr. M. E. Hospitalier will shortly publish a full report of the exhaustive tests carried out.*

The Avenue Trudaine central station of the Compagnie Continentale Edison is now complete, and will shortly be formally inaugurated. The plant comprises four Wehyer and Richemond 300 H.P. engines, each coupled direct to a 300 H.P. double armature 8-pole Edison dynamo. These machines are very similar to some which have lately come into use in the United States (see *The Electrician*, May 15th, p. 34), but they have been somewhat modified by M. Picou. Each Gramme ring armature (2 metres in diameter) has an output of 1,000 amperes and 100 to 120 volts. The two armatures are coupled in series, the distribution taking place at 220 volts on the three-wire system. The machines run at 120 revolutions. The boilers, which are of the Belleville type, are situated in the basement, and the switchboard is on the first floor.

The Société Générale des Téléphones has thought it advisable to announce to the public that the malicious rumours which have been spread with regard to it are without foundation; the Société Générale has not raised the price of its instruments, and does not intend to do so, in spite of the recent decision in the law courts confirming the validity of its patents.

Electricity was well represented at the *fête* given at the Conservatoire des Arts-et-Métiers, on the 25th ult., to celebrate the centenary of the French patent system. The rooms were lighted for the first time from the mains of the Edison Company, and the Société du Théâtrophone had installed a post which was in telephonic communication with the principal theatres. The Société Générale des Téléphones exhibited samples of submarine cables manufactured by them, and amongst the apparatus of historic interest were the first Serrin lamp of 1853, a single-fluid sulphate of mercury cell, made many years ago by Antoine and Edmond Becquerel, and models of the original Planté accumulator and of the original Gaulard transformer.

As a result of considerable cross-questioning in the Chamber of Deputies, M. de Selves has practically disavowed the circular which you published on p. 94 of your last issue, and has now issued the following announcement: "In sending you the circular letter of April 21st, the Administration thought that you would be able to come to an understanding with the Société Générale des Téléphones with regard to the purchase of the telephonic apparatus installed at your house by that Société. Agreement not having proved possible, things will remain in their present state until the termination of the action now pending between the Administration and the Société. But I must ask you not to lose sight of the fact that there is need for you to put yourself in order, as your present position is not in accordance with the undertaking made by you when signing the subscription policy with the State, article 5 of which is as follows. . . . ."

* For descriptions of these meters see *The Electrician*, Vol. XXII., p. 393 (Aron); Vol. XXVI. p. 332 (Thomson-Houston); Vol. XXV., p. 254 (Frager); Vol. XXV., p. 619 (Marès).

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

"THE ELECTRICIAN"

ELECTRICAL TRADES' DIRECTORY & HANDBOOK for 1891.

The 1891 edition of our well-known Directory and Handbook is ready, price 5s., postage extra. The book consists of over 900 pages, and has entailed this year a heavy amount of work. The HANDBOOK DIVISION contains a mass of most useful information. The DIRECTORY DIVISION consists of 430 pages, and contains a very carefully compiled Alphabetical and Classified List of Firms and Persons engaged in the Electrical and Allied Trades in all parts of the world. This Division has been corrected up to date, and the book is thoroughly reliable, the very numerous changes which take place at the beginning of the year being incorporated. By the aidl of this Directory, makers of Electrical Machinery, Apparatus, Instruments, Fittings, Sundries, Novelties, and other goods, may safely communicate direct with probable customers without the annoyance and great expense consequent upon using books which are mere lists of Members of Scientific Societies repeated again and again. The Colonial and Foreign Division of this Directory will be found extensive and reliable. *Orders should be forwarded at once.*

In the course of a few days "The Electrician" Company will publish "THE ELECTRICIAN" PRIMERS in two volumes, price per volume 2s. paper covers, 2s. 6d. cloth.

PLANT FOR SALE.—Our advertisement columns contain particulars of some first-class electrical plant to be disposed of.

DISSOLUTION OF PARTNERSHIP.—The partnership between Mr. Carrington R. J. Smythe and Mr. Ernest Payne, carrying on business at 140, Bath-street, Glasgow, as electrical and mechanical engineers, has been dissolved.

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TENDERS INVITED.—The Local Board for the District of Bishop's Stortford invite tenders for lighting the public streets at present lighted for one year from August 16th. Particulars may be obtained from the clerk, Mr. W. P. Slater, to whom tenders must be delivered not later than 10 a.m. on June 20th.

———. The Commissioners of H. M. Works, &c., invite tenders for the execution of pneumatic and electric bellhangers' work for public buildings, &c., in the London district, for three years from July 1st. Printed schedules and forms of tender may be obtained at H. M. Office of Works, 12, Whitehall-place, S.W., where tenders, addressed to Mr. H. W. Primrose, must be delivered by noon on June 15th.

———. The North-Eastern Railway Company request tenders for supplying telegraph stores for the six months ending December 31, 1891. Forms of tender may be obtained from Mr. Graves, Telegraph Department, York, to whom tenders must be delivered by noon on June 8th.

———. A notification will be found in our advertisement columns that all those interested in the electric lighting of Brussels may obtain a copy of the specifications on applying to the Bureau d'Electricité, 11, Rue de l'Etuve, Brussels.

INTERNATIONAL OKONITE COMPANY, LIMITED.—This Company announce that the extensive additions to their English factory at Newton Heath, Manchester, are now almost completed, and that they will shortly be in a position to offer for trial samples of okonite-covered wires and cables. The Company are manufacturers of every description of insulated wire, either vulcanised, india rubber, gutta percha, or compound, for electric light, power, telephone, or telegraph purposes, and notify in a circular issued to the trade that the okonite dielectric is merely another branch of their existing business. This circular continues:—"In addition, we have erected the most powerful and complete lead covering plant at present in use in Great Britain. We understand that a circular has been issued by a firm of electrical engineers which appears to some of our customers to convey the impression that we are intending to discontinue entirely the manufacture of ordinary high-class vulcanised wires in favour of okonite, and we particularly wish to inform you that this is not the case. On the contrary, we have more than trebled our plant for the production of vulcanised rubber covered wires. We have no special preferential agents, but propose to sell to the trade on as low terms as possible, making allowances for any special orders by way of extra discount. We state in our catalogue (now ready) the E.M.F. which each particular class of vulcanised wire is capable of sustaining, and we are prepared to guarantee this. Should any wire supplied not come up to the standard test we will at once replace it, as our main object is to keep up the highest reputation possible for quality and efficiency."

MESSRS. W. H. ALLEN AND CO.—This firm have secured the contract for the whole of the work in connection with the lighting of the Orient Steam Navigation Company's new twin-screw steamer, "Ophir," which is to be fitted out in a most complete manner. The installation will be a most extensive one, and Messrs. Allen and Co. will supply and install everything in connection with it. There will be four engines and dynamos of the "Allen" patent type. The engines are of the twin compound form constructed for high economy, the dynamos being of the Allen and Kapp improved construction, each capable of giving 300 amperes at 67 volts when running at 230 revolutions. There will be between 900 and 1,000 lights, as well as a projector for use when steaming through the Suez Canal, and mast head and side lights. The whole of the fittings in the saloon will be gold-plated and of an ornamental character, and the work throughout is to be of a most substantial description, similar to that for which Messrs. Allen and Co. have now established a well-earned reputation.

UNITED TELEPHONE COMPANY OF THE RIVER PLATE, LIMITED (IN VOLUNTARY LIQUIDATION).—A meeting will be held at 53, New Broad-street, E.C., on July 1st, at 12 noon, for an account of the winding up.

"ACADEMY ARCHITECTURE."—We have been favoured with a copy of this annual review, which is, no doubt, well known to many of our readers, and which consists of the most prominent architectural drawings hung at the Royal Academy Exhibition, and also contains a view of interesting architectural subjects carried out or designed during recent years in England and abroad. The issue for 1891 is larger than either of its two predecessors, and contains a very large number of handsome designs. The book will be found of use to many outside the architectural profession.

BOOKS, &c., RECEIVED.

"Journal of the Institution of Electrical Engineers." Vol. XX., No 93. (London: E. and F. N. Spon.)

"Telephones, their Construction and Fitting." By F. C. Allsop. (London: E. and F. N. Spon.)

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

May 11, 1891.

8,048. R. KENNEDY. Glasgow. Improvements in dynamo electric generators.

8,053. C. W. R. HAWKESWORTH. Horsforth, near Leeds. An electro-magnetic stop motion, applicable to machinery used in the spinning, twisting, or the doubling, winding of silk, cotton, wool, worsted, flax, jute, hemp, or other fibrous materials.

May 12, 1891.

8,102. J. A. F. ASPINALL and H. A. HOY. London. Improvements in arrangements by which a passing locomotive or train will cause a current of electricity to be transmitted for actuating signals and for other purposes.

8,126. G. J. PHILPOTT. Brighton. Improvements in compound dynamo-electric generators.

8,136. J. CHRISTIANSEN. London. Improvements in electric car motors.

8,141. W. P. THOMSON. Liverpool. Improvements in or relating to treating or manufacturing certain forms of insulated electric conductors (J. B. Williams, United States).

8,150. SIEMENS BROTHERS AND COMPANY (LIMITED). London. Improvements in rotary phase alternative current motors (Siemens and Halske, Germany).

8,151. SIEMENS BROTHERS AND COMPANY (LIMITED). London. Improved means for distributing rotary phase alternating currents to different current consuming apparatus (Siemens and Halske, Germany).

8,153. SIEMENS BROTHERS AND COMPANY (LIMITED). London. Improved means for carrying electro-motors on electrically propelled cars or vehicles (Siemens and Halske, Germany).

8,163. M. W. DEWEY. London. Improvements in electric railways.

May 13, 1891.

8,183. H. D. FITZPATRICK. Glasgow. An improved electric alarm and announcing clock for hotels and factories (S. Schubardt, Germany).

8,198. R. H. HOUSMAN, C. W. DIXON, and S. H. HOLDEN. Birmingham. An improved electricity meter.

8,215. E. J. HOUGHTON. Dulwich. Improvements in single needle speaking telegraph instruments.

8,218. A. R. SENNETT and F. W. CANNON. London. Improvements in dry batteries.

8,225. J. A. F. ASPINALL and H. A. HOY. London. Improvements in arrangements or apparatus for starting, working, and stopping or controlling signals by electricity, also applicable for other purposes.

8,227. W. P. THOMSON. Liverpool. Improvements in electrodes for electric accumulators (H. O. Tudor, Germany).

May 14, 1891.

8,256. P. L. RENOUF. Coventry. Improvements in brazing electrically, such improvements being particularly applicable to the frames of velocipedes.

8,258. H. C L. HOLDEN. Woolwich. Improvements in the construction of electrical vent sealing tubes for firing ordnance and for like purposes.

8,272. J. C. RICHARDSON. London. Electro-magnetic inductography and the electric transmission of light images or telephotography.

8,323. J. GOLDSMID. London. Improvements in thermo electric apparatus (V. Riatti, Italy).

May 15, 1891.

8,363. C. KAHN and W. DANGERFIELD, trading as The National Silex Optical Company. London. Testing sight for astigmatism by means of an electric worked card or disc.

8,378. H. SOUTH. London. Improvements in or relating to resistances for electric current circuits.

8,383. F. MÜLLER and W. GENEST. London. Apparatus for automatically actuating telephones on insertion of coin in payment for the use of same.

8,386. A. T. COLLIER. London. Improvements in microphonic or telephonic transmitters.

8,390. S. TAKASHIMA. London. Improved electrical apparatus for signalling the approach and departure of railway trains.

8,397. W. F. TAYLOR. Croydon. Improvements in methods of automatically regulating alternating current dynamo generators.

8,401. C. N. STANILAND and C. J. STANILAND. London. Improvements relating to electro-photography and to electro-photographic apparatus, applicable also to the preparation of printing surfaces.

8,405. W. W. HORN. London. An improved switch tongue adjuster (J. Mowder and J. S. Mowder, United States).

8,412. W. C. JOHNSON and S. E. PHILLIPS. London. Improvements in the armatures of dynamo-electric machines.

8,413. J. CLEGG. London. Improved means of regulating the preparation of illuminants for incandescent electric lamps.

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May 16, 1891.

8,420. A. Hoster. London. Improvements in or relating to electric hair or skin brushes.

8,457. G. A. Spokes. Northampton. Improvements in electric arc lamps.

8,482. A. S. Bower. London. Improvements in and connected with moulds for casting, more especially intended for use in casting plates for secondary batteries.

May 19, 1891.

8,499. R. E. B. Crompton. London. Improvements in apparatus for controlling electric currents.

8,540. T. J. Moore and E. A. Warren. London. Improvements in conductors for electric railways.

8,555. W. P. Thomson. Liverpool. Improvements in insulated electric conductors (J. B. Williams, United States).

8,573. J. Y. Johnson. London. The manufacture and production of hydrocarbon products or compositions for use for insulating or other purposes (J. Weir, United States).

8,579. C. B. Harness. London. An improvement relating to electrical belts, chiefly designed for medical purposes.

May 20, 1891.

8,609. T. Smith. London. Improved pipes or leads for electric conductors.

8,648. E. Bazin. London. Improvements connected with the use of compressed air for producing electric light and cold.

May 21, 1891.

8,659. A. H. Rowan. London. Improvements in electric tramroads.

8,664. C. Sigmund, Knight of Ilanor. London. An improved storage cable.

8,680. C. W. Cox, W. Robinson, and W. H. Gritton. Liverpool. Improvements in or appertaining to the lighting of ships' signal lamps by electric light.

May 22, 1891.

8,722. J. G. S. Cunnington. London. An improved form of carrier for shades and globes for gas and electric light.

8,735. E. W. Berdoe and G. M. Shum. London. Improvements in electrical storage batteries or accumulators.

8,742. R. Hope-Jones. Liverpool. Improvements in electrical organs or similar instruments.

May 23, 1891.

8,784. S. Evershed and A. E. G. Richards. London. Improved means of, and apparatus for, the transmission of telegraphic signals.

8,798. F. Hanusse and G. Borrel. London. Improvements in electrical signalling apparatus.

8,806. A. I. Gravier. London. Improvements in dynamo-electric and electro-dynamic machines.

8,808. W. J. Green. London. Improvements in and relating to electrical batteries.

8,811. G. Mengarini. London. Improvements in and relating to electric meters.

8,812. A. Hoster. London. Improvements in or relating to casing and covers for electric wires.

SPECIFICATIONS PUBLISHED.

1890.

6,801. Holmes. Electrical conductors. (Price 6d.)

7,932. Elmore. Electrolytically deposited tubes. (Price 6d.)

8,651. Smith. Casing for electrical conductors, &c. (Price 6d.)

9,060. Vialet Chabrand. Ship's telegraph. (Price 1s. 1d.)

9,163. Newton and Hawkins. Electrical switch. (Price 8d.)

10,038. Watt. Electrolytic treatment of metals. (Price 4d.)

10,276. Allison (Ward). Electric search lights. (Price 8d.)

16,607. Bonné (Daniels). Electric switches. (Price 8d.)

21,043. Essick. Telegraphic apparatus. (Price 11d.)

1891.

303. Harding. Electric railway systems. (Price 11d.)

675. Ball. Electric generators, &c. (Price 6d.)

1,988. Imray (The Writing Telegraph Company). Autographic telegraphs. (Price 8d.)

2,443. Westinghouse and Schrender. Switch and signal apparatus. (Price 2s.)

3,364. Lake (Nickerson and another). Incandescent electric lamps. (Price 6d.)

3,675. Edwards (Kunhardt). Electrical currents. (Price 8d.)

4,715. Amstutz. Electrically reproducing uneven, &c., surfaces. (Price 8d.)

5,021. Lake (Gandini). Electric accumulators. (Price 4d.)

5,247. Dewey. Electric heating apparatus. (Price 6d.)

5,280. Thompson (Willing and Violet). Electric switches. (Price 6d.)

5,343. Brockie. Electric arc lamps. (Price 6d.)

5,548. Bishop. Insulated electric conductors. (Price 6d.)

COMPANIES' MEETINGS & REPORTS.

The Notting Hill Electric Lighting Company (Limited).

The annual general meeting of the shareholders of this Company was held on Saturday, 30th May, at Bulmer-place, High-street, Notting Hill, under the presidency of Prof. Wm Crookes, F.R.S.

The SECRETARY read the notice convening the meeting. The minutes of the previous meeting, and the Directors' report and statement of accounts, were taken as read.

The CHAIRMAN: Gentlemen, this is an important meeting in our history, for we to-day inaugurate a system of lighting which I trust will go on continuously night and day for the parliamentary term of 42 years. In formally moving the adoption of the report and accounts, I may mention that the accounts are in the form prescribed by the Board of Trade. From the heading of Form 3, as explained in the Directors' report, it will be seen that the expenditure covers a period of nearly three years, dating from the incorporation of the Company in February, 1888, but the greater part of the expenditure has been incurred during the past 12 months, in erecting the works and machinery and laying the mains. The items in this account speak for themselves, but I may make a few remarks as to the purchase of the Victoria gardens and Bulmer-place properties. Having the opportunity of purchasing the freehold of the Victoria-gardens site, the Directors considered it would be to the interests of the Company to do so, and they therefore effected the purchase as cheaply as possible. A portion of this property is let to Messrs. Sanders, who were interested in the sale. It will also be noticed by the report that it was found desirable to purchase the lease of seven small houses in Bulmer-place, adjoining the works. This was done to avoid waste of time in the erection of the works, as considerable delay was occurring in consequence of injunctions obtained by the owners of the Bulmer-place property against the Company proceeding with the works. I may mention that all the houses are occupied, chiefly by men employed at the Company's central station. In the erection of the central station, 10,000 loads of earth have been removed, and there have been used 1,450 cubic yards of concrete, 700,000 bricks, and 115 tons of ironwork. At present, two boilers 350 H.P. each, two boilers 70 H.P. each, three engines and dynamos, together can supply houses containing 12,000 lamps. The battery station at Phillimore-mews will raise the capacity to 18,000 lamps. Three more boilers and dynamos (costing £6,500) will raise capacity to 50,000 lamps. The Directors very much regret the delay in completing the works, and have done their utmost to overcome the difficulties causing the delay. But as soon as the injunctions were disposed of the exceptionally severe weather of last winter was upon us, making it impossible for the contractors to proceed with the work. The mains have been laid in the principal part of the compulsory area, and comprise about three miles of culverts and five miles of cable. Working, as we do, on the three-wire system, we have thus laid about nine miles of copper strip, or a total of 14 miles of conductor, containing, altogether, 67 tons of copper. The estimated cost of laying the mains has been somewhat exceeded, owing to it having been found absolutely necessary to put down cable instead of strip in many of the streets and roads. I may say that the number of houses wired for lamps is 70; number of houses wired, by which our mains pass, 60; number of lamps, reduced to 8 candles, in houses already wired, about 5,000; number of lamps, reduced to 8 candles, in wired houses, by which our mains now pass, 3,500; estimated number of lamps on our mains by the end of the year, 7,500; estimated revenue per 8-candle lamp per annum, 10s.; estimated income from 7,500 lamps, £3,750. It is proposed to extend at once to Westbourne-grove. This will bring in a further revenue of about £300 a year. An accumulator station is being arranged for in Phillimore-mews. This will give us greater facilities for supplying houses in our southern district. A new site for the second central station is in treaty for near Addison-road. This will give us command over the rich district of Addison-road, Addison-gardens, Melbury-road, and the two acres of good houses which are to be erected in Holland Park. The Directors have every reason to hope that this second station will be self supporting from almost its commencement. The Directors have made an application to the Committee of the Stock Exchange for a quotation of the Company's shares on the official list, and we have every reason to believe this will soon be granted. The delay has arisen owing to the necessity of being able to say that the works were actually open and supplying current. Not a single fault or leakage has been found in our system of mains. This speaks well for the excellence of the mains and cable, and the skill and care of the engineering staff. The light has been supplied to a few houses, experimentally, for some weeks, during which time it has been subjected to careful tests as to steadiness and uniformity. No fault has been detected. For the present we expect to run entirely from batteries, which will be charged a few hours a day, increasing as the load increases. At present we charge the batteries for two hours a day. I move:—

"*That the report of the Directors, and the accounts for the period commencing February 21, 1888, and ending December 31, 1890, submitted to this meeting, be, and the same are hereby, approved and adopted.*"

Mr. SIDNEY WATERS seconded the motion.

Mr. GAMBLE thought that £4,000 was a very large sum to pay for the license, provisional order, and preliminary expenses. With regard to the general balance-sheet, he found that, after spending apparently all the money that had been raised, they had still a deposit at the bank of £6,000. How was that to be explained?

The CHAIRMAN: In reply to the first question, I may say that the item includes the whole of the preliminary expenses. These extended over

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two years, and in addition to the usual charges connected with registration, advertising, and brokers' fees, include heavy law costs, counsels' fees, and Parliamentary agent's expenses incurred during the long fight before the Board of Trade and both Houses of Parliament.. This item appeared in the original prospectus issued to the public in January, 1890. At the 31st December, 1890, we had spent £43,126, and we had £6,666 cash in hand, and there was uncalled capital as well to the amount of about £27,444.

Mr. GAMBLE: Share capital?

The CHAIRMAN: Yes, ready to call.

Mr. GAMBLE: But still I cannot see how that amount of cash can be at the bankers.

The CHAIRMAN: It was there in cash on December 31st.

The SECRETARY said that as against the cash in hand they had certain liabilities which had to be met out of it. It was a mere question of book-keeping.

Mr. FRANKLIN explained that the Board of Trade compelled them to close their books on December 31st, at which date there were some people to whom they owed certain bills, and the money was merely lying at the bank ready to be drawn.

Mr. REEVES asked whether it was possible for the Chairman to say when the Company would be able to supply current to the Phillimore estate.

The CHAIRMAN: The engineer will probably answer that.

Mr. REEVES: Probably you will do so in the course of next winter.

The CHAIRMAN: I scarcely think it will be so long as that.

The ENGINEER (Mr. J. Crookes): It will take about eight months to do so.

The resolution was then formally put to the meeting, and carried unanimously.

The CHAIRMAN: According to our Articles of Association two of the Directors retire by rotation, and, being qualified, they offer themselves for re-election. I therefore move—

"*That the retiring Directors, Messrs. Alexander Howden and James Thomas Jarvis, be re-elected.*"

Mr. ROMER seconded the motion, which was agreed to *nem. con.*

Mr. HOWDEN, in acknowledging the re-election of himself and colleague, assured the meeting that nothing would be wanting on their part to merit the renewed mark of confidence of the shareholders.

On the motion of Mr. BENSON, seconded by Mr. REEVES, the auditors, Messrs. Deloitte, Dever, Griffiths and Co., were unanimously reappointed.

Mr. GAMBLE proposed, and Mr. ROMER seconded, a vote of thanks to the Chairman, which was cordially passed.

The CHAIRMAN briefly acknowledged the compliment, and the business of the shareholders' meeting ended.

A meeting of the general public of the district to be supplied by the Company was held afterwards in the main building of the works, to hear a statement from Prof. Crookes, explanatory of the Company's operations, and the principle on which the electric light is to be supplied, and to formally turn on the electric current. There was a large attendance of both ladies and gentlemen, and

Prof. CROOKES, who received a cordial reception, spoke very hopefully of the prospects of electric lighting generally, and in reference to the prospects of the Notting Hill Company in particular. He related how, about 10 years ago, he inaugurated probably the first installation of the electric light in a private dwelling. He remembered, when the excavations were being made for the dynamo and engine, that there was very great curiosity in the neighbourhood as to what he was doing, and the very workmen who were doing the work got rather confused between dynamo and dynamite; in fact, there was a report in the district that he was making a dynamite factory, and the consequence was that his immediate neighbours began to get rather anxious. But that time had now passed away. Prof. Crookes then gave the meeting a general idea of the plant necessary for lighting a large district, and showed how fully the Notting Hill Company had provided for eventualities, claiming for his Company all the advantages of the low-tension system. If you took it light for light, the electric light was not as cheap as gas, any more than wax candles were. But it was really much cheaper than gas if incidental savings were taken into consideration. Thus, with electricity the ceilings do not get blackened, the wall papers do not become soiled, the curtains and drapery do not get dirtied by smoke, decorative paintwork is not deteriorated, gilding remains as fresh as when first applied, bindings of books are not rotted, and oil and water colour paintings are not injured by the sulphur of gas; the air we breathe in the room is always sweet and fresh and is not loaded with hot products of combustion, while fire risk is almost annihilated, as no matches are required. If anyone present would reckon up what he pays every year under the above headings, and add the amount to his average gas bills, he would find that the expense of electric lighting was far below that of gas. Another saving was effected owing to the electric light being so easily turned off and on. With the switches near the door, as they ought to be, one soon gets in the habit of turning the lights off when leaving a room, and only turning them on on entering. No matches being required, this involved no trouble.

Prof. Crookes concluded his interesting discourse amid the hearty plaudits of the assembly, and a cordial vote of thanks was passed to Prof. and Mrs. Crookes and the other Directors of the Company, for having so successfully carried out and launched their undertaking; and, in reply, Prof. Crookes asked that full credit should be given to his co-directors, who had worked very hard to bring about the success which he had been able to chronicle. Their thanks were also especially due to their engineers, Messrs. Crompton, and to Mr. J. E. Spagnoletti and to their secretary, Mr. Fox. Mr. Schultz was the resident engineer, and they could see the kind of work he had done. Mr. Slater, the architect, had done wonders, too, in getting an immense mass of machinery, batteries and appliances of all kinds, into rather limited space. To all these gentlemen their thanks were due. The audience, having inspected the works and plant, then dispersed.

Anglo-Portuguese Telephone Company (Limited).

The following is the report of the Directors, to be presented at the adjourned fourth ordinary general meeting of the Company, to be held at the offices of the Company, 53, New Broad-street, E.C., on Thursday, the 11th June, 1891, at 3 o'clock p.m.:—

The Directors beg to submit to the shareholders their report and accounts of the Company for the year ending December 31, 1890. The amount to the credit of profit and loss account, after making all deductions, and including the balance brought from last year, is £6,193. 15s. 6d. Out of this an interim dividend of 5 per cent. has since been paid, absorbing £2,500, and of the balance it is now proposed to place £2,500 to reserve, and to carry forward £1,193. 15s. 6d. to the current year's accounts. The expenditnre on capital account for the year amounted to £6,589. 4s. 9d.

The number of paying subscribers at December 31st last was—in Lisbon, 1,024, of a gross annual value of £7,530; in Oporto, 983, of a gross annual value of £5,391, £12,921, showing a total increase in subscribers of 152, and in value of £1,033, over the preceding year.

The Directors are pleased to announce that the Conde De Gouveia and Mr. Pinto-Basto have rejoined the Lisbon Board, and that Dr. Marcal Pacheco has been re appointed the Company's legal adviser in Portugal. Mr. C. L. W. Fitzgerald, of the London Board, and the Conde De Gouveia, of the Lisbon Board, are the retiring Directors at the forthcoming general meeting, and, being eligible, offer themselves for re-election. The auditors, Messrs. Deloitte, Dever, Griffiths and Company, being eligible, offer themselves for re-election.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The Directors of this Company have declared an interim dividend of 5s. per share, free of income-tax, for the quarter ended March 31st last, and payable on the 24th inst. The transfer books will be closed from the 17th to the 23rd inst., both days inclusive. The traffic receipts of this Company for the past week amounted to £4,794.

CITY AND SOUTH LONDON RAILWAY COMPANY.—The traffic receipts of this Company for the past week amounted to £768. The aggregate receipts for the half-year to date are £16,143.

CUBA SUBMARINE TELEGRAPH COMPANY.—The estimated traffic receipts of this Company for the month of May were £3,600, as compared with £3,409 in the corresponding month of last year.

DIRECT SPANISH TELEGRAPH COMPANY.—The traffic receipts of this Company for the month of May, 1891, amounted to £2,163, as against £2,244 in the corresponding period of last year, or a decrease of £81.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this Company for May were £53,829, as against £53,373 for the same period of 1890, an increase of £456.

EASTERN EXTENSION TELEGRAPH COMPANY.—The receipts of this Company for May amounted to £37,064, as against £41,230 in the corresponding period of last year, showing a decrease of £4,166.

ELECTRIC AND GENERAL INVESTMENT COMPANY (LIMITED).—A notice appears in our advertisement columns that the share transfer books and register of members of this Company will be closed from June 3rd to June 17th, both days inclusive, for the purpose of preparing the dividend cheques.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of this Company are as follows:—Receipts in May, 1891, £26,000; 1st January to 31st May, 1891, £114,000; corresponding months, 18.0, £105,800; corresponding months, 1889, £106,800.

NEW COMPANIES REGISTERED IN MAY.—Out of a total capital of £9,867,618 in new companies registered during May, electrical undertakings are, says the *Financial Times*, reponsible for £311,000.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended May 29, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,879.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The receipts of this Company for the two weeks ended May 31st amounted to £2,779, as compared with £3,256 for the corresponding period last year, showing a decrease of £477.

CRICKET.—Woodhouse and Rawson United (Limited) v. The Electric Construction Corporation (Limited).—A match between these elevens was played on Saturday last, at Walthamstow, and ended in a victory for the former. Scores:—

ELECTRIC CONSTRUCTION CORPORATION (LIMITED).—Shaw (leg b w, b Tasker) 27, Fraser (run out) 13, Spears (b Sellick) 0, Sage (b Foley) 13, Clark (c Moore, b Howell) 14, Davidson (b Long) 5, Oxley (c and b Long) 1, Collins (b Long) 1, Frower (not out) 0; extras, 9—total 83. (E. C. C. batted two short).

WOODHOUSE AND RAWSON UNITED (LIMITED).—A. L. Foley (b Sage) 22, H. C. Foy (b Sage) 4, W. R. Long (not out) 40, R. D. Holtz (b Sage) 9, Tasker (not out) 1; extras, 10—total 86. Stutchbury, Taylor, Sellick, Moore, Jones, and Howell did not bat.

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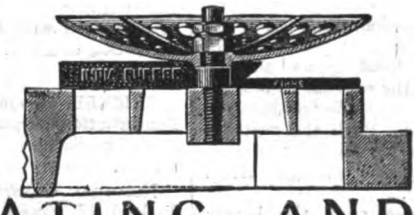
COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, May 27.	Price Wednesday, June 3.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending June 3. Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
£1,381,380	Stock	12/0	Anglo-American	46½ 47½	46½ 47½	6 0 0	Jan., Apr., July, Oct	47	..
£2,809,310	Stock	21/0	Do. Preferred	84½ 85½	84 85	6 15 4	" " "	85½	85
£2,809,310	Stock	..	Do. Deferred	11½ 12	11½ 11¾	..	.. ..	11¾	11½
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99 102	99 102	3 18 5	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	11¾ 12¼	11¾ 12¼	6 2 5	Mar., June, Oct., Dec.	12 1/16	11½
£84,500	£100	5%	Do. 5 per Cent. Bonds	101 104	101 104	4 16 2	January and July ..	..	..
£75,000	£10	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	104 108	104 108	4 12 7	June and December	..	..
$7,216,000	$100	7%	Commercial Cable Capital Stock	106 108	106 108	6 0 4	April and October ..	..	..
16,000	10	8/0	Cuba Submarine	10½ 11½	10½ 11½	6 19 2	February and August	..	..
6,000	10	10%	Do. Preference 10%	16½ 17½	16½ 17½	5 14 3	" "	17½	..
12,931	5	3 3/4	Direct Spanish (£4 paid)	3¾ 4½	3¾ 4½	6 11 9	April and October ..	..	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	.. ..	..	..
60,710	20	3/6	Direct United States	10½ 10¾	10½ 10¾	6 13 4	Jan., Apr., July, Oct.	10¾	10 5/16
400,000	10	2/6	Eastern	14⅝ 14¾	14⅝ 14¾	4 8 10	" "	14¾	14⅝
70,000	10	6%	Do. 6 per Cent. Preference	15½ 15¾	15 15½	3 17 5	" "	15½	..
£1,200,000	Stock	6%	Do. 4 per Cent. Mort. Debenture Stock	106 109	106 109	3 13 5	May and November	..	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	107 110	4 10 11	February & August	..	..
250,000	10	6/6	Eastern Extension	14¾ 15	14¾ 15	4 13 4	Jan., Apr., July, Oct.	15	14⅝
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock	105 108	105 108	3 14 1	.. ..	105½	..
£91,800	100	5%	Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	103 106	103 106	4 14 4	January and July ..	103½	103½
£145,300	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	103 106	103 106	4 14 4	" "	103½	..
180,227	10	2/6	Globe Telegraph and Trust	9½ 9¾	9⅝ 9⅝	5 6 6	Jan., Apr., July, Oct.	9½	..
180,042	10	6%	Do. 6 per Cent. Preference	15 15½	15 15½	3 18 8	" "	15½	15
150,000	10	7/2	Great Northern	18 18⅛	18¼ 18¾	4 11 6	Jan., April, and July	18½	18¼
£15,000	100	5%	Do. 5 per Cent. Debentures, 1881	.. ..	.. ..	..	January and July ..	..	..
£23,000	100	5%	Do. 5 per Cent. Debentures, 1883	105 108	105 108	4 12 7	March & September	..	..
17,000	25	12/6	Indo-European	39 41	39 41	4 11 6	May and November	40½	..
38,348	10	4/0	London Platino-Brazilian	6½ 7½	6½ 7½	6 0 0	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106 109	106 109	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's	8 8½	8 8½	4 14 1	April and October ..	..	..
3,381	£100 Cert.	6%	Submarine Cables Trust 6%	115 120	114 118	5 1 8	" "	118	..
15,609	10	4/0	West African Telegraph	8 9	8 9	5 11 1	January and July ..	..	..
£230,900	100	5%	Do. 5 per Cent. Debentures	96 99	96 99	5 1 0	March & September	..	..
30,000	10	3/0	West Coast of America xd	3½ 4½	3½ 4½	..	January and July ..	..	..
£150,000	100	8%	Do. Debentures 8% 1902	100 105	100 105	7 12 5	June and December	101¾	..
88,321	10	9d.	West India and Panama xd	2½ 3½	3 3½	..	..	3 3/16	3½
34,563	10	6/0	Do. 1st Preference 6% xd	11⅜ 12½	11½ 12	5 0 0	May and November	11⅝	11 11/16
4,669	10	£3	Do. 6 p. c. 2nd Pref.	11½ 12½	9½ 10½	5 14 3	" "	..	..
64,174	15	6/0	Western and Brazilian	11 11½	11 11½	6 10 7	" "	11 5/16	11½
27,873	7½	6/0	Do. 5 per Cent. Cumulative Preferred	6½ 7	6½ 7	5 7 3	—	6 13/16	..
27,873	7½	4/6	Do. 5 per Cent. Deferred	4¾ 5½	4½ 5	..	..	5	4⅝
£200,000	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103 106	104 107	5 12 2	February & August	..	..
£250,000	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103 106	103 106	5 13 2	" "	105	104½
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	117 122	5 14 9	May and November	..	..
£175,100	£100	6%	Do, 6 per Cent. Sterling Bond	100 104	100 104	5 15 5	March & September	..	..
			TELEPHONES.						
224,850	14/0	0/4½	Consolidated Telephone Const. & Maintenance	½ ⅝	½ ⅝	6 14 5	May and November	½	..
220,000	£1	4·76	Oriental (11s. paid)	¼ ⅜	¼ ⅜	5 2 11	Yearly	..	..
438,984	5	2/6	National	4⅜ 4½	4⅜ 4½	5 12 10	June and December	4 3/16	4 3/16
15,000	10	6/0	Do. 6 per Cent. Cumulative 1st Pref.	12½ 13	12½ 12⅝	4 14 1	" "	13	12⅝
15,000	10	4/9⅜	Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd)	12 12½	11⅞ 12¼	3 18 5	" "	..	..
..	£100	..	Do. Debenture Stk. 4½% Prov. Cert. (fully pd)	103 105	104 106	..	..	105½	104
209,750	1	..	South of England, Ordinary	.. ..	.. ..	..	—	..	..
20,000	5	..	Do. 6 per Cent. Cumulative Pf. (£3 10s. pd)	.. ..	.. ..	..	—	..	..
58,000	5	1/0	United River Plate	2½ 3½	2½ 3½	..	January and July ..	..	..
£146,128	Stock	5%	Do. 5 per Cent. Debenture Stock	85 95	85 95	5 5 3	..	..	..
£3,200	100	..	Do. 7 per Cent. Debentures	.. ..	.. ..	..	—	..	..
			ELECTRICITY SUPPLY COMPANIES.						
1,000	£50	..	City of London Electric Lighting Shares (£25 pd)	32 34	30 34	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	4½ 5	4½ 5	..	..	..	..
5,322	£5	3½%	House to House Electric	4½ 5½	4½ 5½	..	..	..	..
30,000	£5	..	Liverpool Electric Supply (£3 paid)	2⅜ 2⅞	2½ 2⅝	3 13 1	..	..	..
111,000	5	..	London Electric Supply	2⅛ 2⅜	1⅞ 2⅛	..	..	..	..
43,900	10/0	2/0	Metropolitan Electric Supply (£9 paid)	9 9½	8½ 9½	4 7 7	..	9 5/16	..
7,730	£5	..	St. James' and Pall Mall	5⅞ 6½	.. ¼	..	..	..	..
..	..	..	Do. 7% Preference	⅝ ¾ prem.	⅝ ¾	..	..	..	..
42,853	5	..	Westminster Electric Supply (£5 paid)	4¼ 5½	4½ 5	..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
63,416	3	..	Brush Electrical Engineering	2½ 2⅞	2½ 2⅝	..	..	2 1/16	2 1/16
63,416	2	1/1	Do. 6 per Cent. Preference	1⅝ 1⅞	1⅝ 1⅞	6 8 0	June and December	..	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	4 5	4 5	7 0 0	January and July ..	..	..
17,130	5	..	Edison and Swan United	.. ..	.. ..	..	—	..	..
45,000	10	6%	Electric Construction	5 6	5 6	..	—	5½	..
70,000	2	10/0	Elmore's Patent Copper Depositing	2½ 3	2½ 3	..	—	3⅛	2⅞
20,000	5	..	Fowler-Waring Cables (£4 paid)	2½ 3½	2½ 3½	..	..	..	..
41,000	10	10/0	India Rubber, Gutta Percha & Telegraph Works	18½ 19½	18½ 19½	5 2 7	February & August	19¼	18⅝
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	March & September	..	..
11,334	£10	6/1	International Okonite Limited Ordinary	7½ 8½	7½ 8½	11 15 3	..	..	..
11,334	£10	5/0	Do. Preference	9¼ 9⅝	9¼ 9⅝	8 4 1	..	..	..
78,949	5	4/10½	Swan United (£3. 10s. paid)	4¼ 4¾	4½ 5	6 19 10	May and November	4 1/16	4½
37,350	12	36/0	Telegraph Construction and Maintenance	46 48	46 48	5 0 0	March and July	47	46¼
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	102 105	102 105	4 15 3	January and July ..	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£3 paid)	2½ 2⅝	2½ 2⅝	..	..	..	..
—	£5	..	Do. Preference (fully paid)	3⅞ 4⅛	3¾ 4⅛	..	..	..	..
			RAILWAYS.						
50,000	£10	..	City and South London Railway	5 6	4 5	..	..	4 1/16	..

NEW VALVE



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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

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NOTES.

On Tuesday last the unusual process of reviving a patent by a special Act of Parliament was exemplified by the third reading and passing of the Worms and Balé Patent Bill in the House of Lords. It will be remembered that the British Tanning Company, who are the owners of this patent, and who have been engaged in the tanning of leather on a considerable scale with the assistance of electricity, brought an action against Mr. Groth for infringing their patent, which practically consists in the use of a rotating drum containing the hides and liquor. But while they failed to show an infringement, their patent was invalidated by prior publication, through an American patent abridgement. The patentees had omitted to avail themselves of the then newly-constituted International Convention, and thus lost their patent. Had the action of the British Tanning Company *v.* Groth (which was fully reported in *The Electrician*, p. 341 and p. 369, Vol. XXVI.) shown that the invention of Worms and Balé consisted in the wider idea of the combination of electricity and motion, the revival of their patent would be a matter of very considerable importance, for the effect of an electric current in hastening the process of tanning is well established, and it might have been held that such a combination was actually a "method," and not a principle; but no such broad claim was made, and the revived patent must be restricted to the use of the revolving drum.

The researches of Dr. Lodge in connection with the subject of lightning discharge have been very fully treated in *The Electrician*, but it seems that the experiments have been even more numerous than those hitherto published. In a lengthy Paper, read at the last meeting of the Royal Society, the learned Professor gave a detailed account of a number of his earlier experiments. Many of these, it is true, have been previously described, but the actual measurements made, and the practical details of the apparatus, have not been published before. These early experiments are of special interest, as they deal with the subject of electro-magnetic waves, and clearly show how very near Dr. Lodge was to foreatall Prof. Hertz in his important work. Indeed, if it had not been for the fact that the mind of the English investigator happened to be bent on the study of lightning conductors, the probabilities are that most of the discoveries of Hertz would have been arrived at simultaneously and independently by the two physicists. Even as it is, the work of Dr. Lodge is so similar to that of Prof. Hertz that the names of the two investigators will always be linked together in describing the epoch in electrical science brought about by their efforts. We may call attention to the fact that Prof. Lodge will show "some experiments with Leyden jars" at to-day's meeting of the Physical Society, and those of our readers who are able to attend will have the opportunity of seeing some interesting experiments.

At the same meeting of the Royal Society a Paper on "Quadrant Electrometers," by Profs. Ayrton and Perry, and Dr. Sumpner, was read and discussed. It describes an investigation which has taken a long time to complete, and contains a considerable amount of much-needed information with reference to the behaviour of electrometers when the potential of the needle is varied. It has been known for some time that the ordinary law, given in mathematical text books, connecting the deflection of the instrument with the potential of the needle, and the voltage between the quadrants, is not fulfilled, and that, in consequence, the instrument cannot be used for the measurement of power supplied by alternate currents. The extent to which the law is inaccurate, and the circumstances which influence the error, have, however, not been at all well understood, and few experiments have been made on the subject, as they are difficult to carry out. These matters have been thoroughly investigated, and we shall refer to them at greater length when the complete Paper appears in print. In the meanwhile, the chief results of the work may be very briefly summarised. According to the authors of the Paper, the chief cause of the peculiar behaviour of the White electrometer is the electrical action between the guard tube and the needle, and also the slight tilting of the needle which occurs at high potentials. The writers also make the important observation that, according to the adjustments of the quadrants, the deflection, for a given difference of potential on the quadrants, may be made either nearly independent of the potential of the needle or directly proportional to it, or to increase more rapidly than the potential of the needle. In one case the adjustment of the quadrants was such that the deflection did not alter appreciably, while the potential of the needle was raised from 2,000 to 3,000 volts.

A description is given of an improved form of instrument, in which the errors due to the presence of the guard tube are eliminated, so that the ordinary law is fulfilled. In this instrument the control is magnetic, as in the original specimens of the quadrant electrometer. The bifilar arrangement, afterwards adopted by Sir William Thomson, has been abandoned, because

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the authors find that greater sensibility can be obtained with a unifilar control, while external magnetic disturbances can be sufficiently reduced by using an astatic combination of magnets on the moving parts of the instrument.

MR. MERRITT'S note, which we publish in this issue, relates to the behaviour of galvanometers while the needle is actually in motion. Neither the phenomena described, nor the explanation given of them, present any striking points of novelty. When a current is suddenly passed through the coils of a galvanometer the needle swings about its new position of equilibrium for some time; and if, while this action is going on, the current itself varies, the motion of the needle is compounded of the motion corresponding with the change of current strength, and that corresponding with the natural oscillations of the needle. Moreover, if the variation of the current takes place according to any fixed law, the magnitude of the first swing must always be proportional to the final deflection of the needle. The experimental proof of these statements is, however, a matter of some interest, and Mr. MERRITT has done well to call attention to the considerable saving in time and gain in accuracy which can often be obtained by making use of the first swing, instead of the final deflection, for purposes of measurement. In Mr. MERRITT'S valuable investigation on the energy of the light given out by glow lamps, the method was used chiefly on account of its rapidity, as many sources of error were thereby eliminated. The swing method in these experiments was less sensitive, because of the final deflection being greater than the initial impulse of the needle. Sometimes, however, the reverse holds good, as, for instance, when the value of a steady current is estimated from the swing produced by suddenly passing it through the coils of a galvanometer. Here not only is the time necessary for an observation much less, but the actual deflection is generally twice as large.

Royal Meteorological Society.—Notice of Removal.—On May 20th, the offices and library of this Society were removed from 30, Great George-street, to more commodious rooms at 22, Great George-street.

Electric Traction in Spandau.—A 50 years' concession for working electric railways in Spandau has just been granted to the International Electric Company of Boston. Work has to be commenced within three months.

Electrical Bills in Parliament.—The following Bills were read a third time in the House of Lords during the week and passed:—London Overhead Wires Bill; Electric Lighting Bills Nos. 1, 2, 3, and 4; Worms and Balé Patent Bill.

Lightning.—A company of soldiers at drill, near Berlin, were struck by lightning on Tuesday morning. A great number of soldiers were rendered insensible, the captain's horse was killed, and a soldier who was holding the bridle was dangerously wounded.

Larne.—At a special meeting of the Town Commissioners, last week, the tender of Messrs. Gordon and Co. to light the town with 10 arc lamps of 1,200 c.p. each, and 49 incandescent lamps of 16 c.p. each, for the sum of £200 per annum, from 1st August to 30th April, was accepted.

Compagnie Francaise des Telegraphes Sous-Marins.—The "Westmeath" has laid the Puerto-Plata-Martinique section of this Company's cable system, and the "Ludaate" has just sailed for the West Indies with the section connecting Guiana with Brazil.

Small Electric Motors.—The *Elektrotechnischer Anzeiger* states that the Berliner Elektricitätswerke is about to reduce its charges for motive power, so that small electric motors will be able to be run at a lower cost than those using any other form of energy.

Liverpool.—At the last monthly meeting of the City Council the Watch Committee brought forward a scale of charges for testing lines and mains, recommended by them to be made under the Liverpool Electric Lighting Order, 1889, and this schedule was passed without discussion.

The Paris Telephone Exchange.—The building of the Paris Central Telephone Exchange, says our Paris correspondent, is proceeding with great rapidity, and the shell will be completed by the autumn, and the exchange come into operation by the beginning of 1892.

Overhead Electric Traction Wires and the Telephone.—The German postal authorities are about to institute proceedings against the Allgemeine Elektricitäts Gesellschaft, owing to the disturbances caused in telephonic circuits by the Company's electric tramway at Halle, on which the Sprague system is used.

Newcastle.—At a meeting of the Town Council, last week, the Town Clerk reported that the petition against the Newcastle Electric Lighting Bill had been sent to the Board of Trade, and they had received a letter from the Board of Trade to the effect that they had conceded all the points in the petition

Copper.—The price of fine bars, which was £51. 12s. 6d. at the end of April, had advanced to £55. 5s. by the end of last month. The supplies during May amounted to 9,672 and the deliveries to 11,180 tons. The stocks in hand are now 57,808 tons, as against 59,316 tons at the end of April and 82,041 tons this time last year.

The Austrian Society of Electricians.—At the end of 1890 this Society consisted of 569 members, of which 255 inhabit Vienna, and 207 inhabit the provinces, 107 being foreign members. The annual revenue of the Society is £640, of which £420 comes from subscriptions and £110 from the sale of the journal, the cost of the bringing out of which amounts to £360.

The Faraday Centenary.—The Prince of Wales has fixed 4 o'clock on Wednesday, June 17th, for the delivery by Lord Rayleigh of the first of the two lectures at the Royal Institution in connection with the centenary of the birth of Michael Faraday, and Friday evening, June 26th, at 9 o'clock, has been appointed for the second of these lectures, which will be given by Prof. Dewar.

The Telegraph Battalion of the Royal Engineers.—The 1st Division of this Battalion is engaged, as a summer exercise, in running a field telegraph line from Aldershot to Chatham. From Aldershot to Chevening, near Sevenoaks, a distance of 50 miles, the line was erected in less than 30 hours, which is said to be the smartest feat of the kind on record. Light bamboo poles are used as supports.

Obituary.—The death is announced of Dr. W. E. Steavenson, from influenza and bronchitis, on June 1st, at the age of 41. In 1883 he took office at St. Bartholomew's as casualty physician, and during this period was appointed physician to the newly-created electrical department at that institution, a post which he continued to fill to the day of his death. Dr. Steavenson wrote several Papers on subjects connected with the electrical treatment of disease, and last year he published his book on "Electrolysis in Surgery."

The North London Steam Trams.—These cars will shortly cease running in consequence of an agitation set on foot some months ago by the residents at Finsbury Park and neighbourhood. The Board of Trade has now refused to grant a renewal of the running powers of the North London Steam Tramways Company between Finsbury Park, Wood Green, and Edmonton. The steam cars were not running in accordance with Board of Trade requirements, and the engines were not kept in good order. They will cease to run on and after June 15th.

Royal Society.—The following Papers were down for reading before the Royal Society yesterday:—Sir William Thomson,

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Pres. R.S., "On a Test Case of the Boltzmann-Maxwell Doctrine regarding Distribution of Energy." W. Crookes, F.R.S., "On Electrical Evaporation." G. H. Robertson, "A Study of the Planté Lead-Sulphuric Acid-Lead Peroxide Cell, from a Chemical Standpoint. Part I." Prof. Armstrong, F.R.S., and G. H. Robertson. "Part II.—A Discussion of the Chemical Changes occurring in the Cell." H. Wilde, F.R.S., "On the Influence of Temperature upon the Magnetisation of Iron and other Magnetic Substances."

York.—The members of the electric lighting committee and the streets and buildings committee of the York Corporation held a joint meeting last week, to consult with Mr. R. E. Crompton—who some time ago was appointed the consulting electrical engineer of York—on the proposed scheme for the introduction of the electric light into the city. Mr. Crompton was in favour of the low-pressure system. After considerable deliberation on the matter, Mr. Crompton was requested to furnish a report on the subject, with special reference to the cost of laying down the necessary plant, the cost of maintenance, &c.

Societe Generale des Telephones.—At the meeting of the shareholders of this Company, on the 3rd inst., a dividend of 18fr. per share was declared and 79,625fr. were carried to the reserve fund. MM. Lair and Viguier were re-elected Directors, and M. Lazare Weiler was authorised to remain a Director, while retaining his post of Managing Director of the Société des Usines d'Angouleme, which supplies a large amount of material to the Société des Téléphones. MM. Lair, May, Wallerstein, and Viguier, were similarly authorised, they being also Directors of the Compagnie des Télégraphes Sous-Marins. MM. Kulp, de Sainte-Marie, and Petit were re-appointed managers.

Electric Wires in Glasgow.—A very serious fire broke out, early on Monday forenoon, in Miller-street, Glasgow, which played sad havoc among telephone and telegraph wires. No less than twenty telephone lines were interrupted. Eleven of the wires were in connection with the National Telephone Company's local exchange, and the rest were private lines. Three fire-alarm wires were also destroyed, and Messrs. Muir, Mavor, and Coulson had to clear away one of the branch mains for supplying their customers with electric current. Although the main was in such close proximity to the fire only one customer was temporarily cut off.

Asbestos in New South Wales.—The Government Geologist of New South Wales, according to the *Sydney Morning Herald*, has received several samples of asbestos, which were discovered at Red Hill, near Broken Hill. The asbestos was obtained in a vein measuring from 2½ft. to 3ft. in width, at a depth of 10ft. from the surface. Some of it contains fibre 13in. long, the texture being silky and flexible. The Broken Hill material is not, however, as strong or tough as the Italian asbestos. The colour too, is different, as the Broken Hill asbestos is reddish in hue, owing to the presence of iron oxide. It is expected that a whiter mineral will be found at a greater depth. Several tons of asbestos have been brought to surface.

Cataphoric Medication.—It was César Antoine Becquerel says *L'Electricité*, who discovered the phenomenon of transportation by the electric current, and who utilised it before 1830 in the artificial formation of crystals. A few years later he applied his discovery to the study of vegetable physiology, and investigated in a thorough manner the modifications produced by the electric current in the endosmose and exosmose of vegetable substances, and of membranes of animal origin. The scientific theory of the introduction of medicaments into the human body was in this way founded. The first direct application to medicine was made by Dr. Fabri-Pelleport, who died in 1838. Renewed attempts were made in London, in 1859, by Dr. Richardson, who extended his researches to aconite, morphine, and chloroform.

The Cultivation of India-rubber and Gutta-percha.—Something like 1½ tons of india-rubber were recently sold in Amsterdam, the product of trees planted about 10 years ago in Java. The prices obtained were said to be excellent. The care needed to cultivate rubber begets the same quality in gathering, remarks the *India Rubber World* of New York, and it is well known to manufacturers that many an inferior rubber would come into favour if it were not so full of rubbish, which requires expensive labour to eliminate. In Algeria the cultivation of the gutta-percha tree is to be begun by extensive planting of trees under the superintendence of French Government officials. As it takes a tree 25 years or more to reach maturity, the plantation of gutta-percha trees is not very likely to attract private enterprise.

The Fothergill Prize.—Under the will of Dr. Fothergill (1821), funds were bequeathed to the Society of Arts for the offer of medals for subjects, in the first instance, relating to the prevention of fire. A Society's gold medal, or £20, is now offered for the best invention having for its object the prevention or extinction of fires in theatres or other places of public amusement. In cases where the invention is in actual use, reference should be made to places where it could be inspected. A full description of the invention, accompanied by such drawings or models as are necessary for its elucidation, must be sent in on or before December 31, 1891, to the Secretary of the Society of Arts, John-street, Adelphi, London. The Council reserve the right of withholding the prize in case there is nothing in their opinion deserving the award, or sufficiently complying with the conditions, sent in for competition.

Electric Launches on the Thames.—On Monday afternoon last two additions were made to the Thames electric launch fleet by the floating, from the Strand Electric Launch Works, at Chiswick, of the "Glowworm" and the "Myiomi." These boats have been designed by Mr. W. S. Sargeant, branch manager to Woodhouse and Rawson United. The "Glowworm" is 53ft. long, with 7ft. 2in. beam, has a draught of 2ft. 6in., and displacement of 5¾ tons. She is built of bright mahogany with teak fittings. She will carry 40 passengers, make about nine miles an hour, is lighted as well as propelled by electricity, and carries a search light. The "Myiomi" is 35ft. long, with 5ft. 6in. beam, and 18in. draught, and a displacement of 3¼ tons. She is constructed of mild steel, with teak fittings; her electric arrangements are similar to those of the "Glowworm," but there is no search light. Her speed will also be about nine miles an hour.

The Electrolysis of Animal Tissues.—In a recent Paper on this subject, entitled "Studies from a Physiological Laboratory," Mr. G. N. Stewart says that it seems that practically the whole of the conduction in animal tissues is electrolytic, and the electrolytes are principally the mineral salts, changes in the proteids being produced by secondary electrolytic actions. In simple proteid solutions, conduction occurs with great difficulty if mineral salts are absent, or if they are present only in small proportions. The effects on the proteids themselves in saline solutions vary somewhat with the current density. The effects of electrolysis on the salts of the muscle were studied by estimating the ash. Striking changes were found to occur which, if produced within the living body, would profoundly modify nutrition. The antiseptic action of the current was studied in the case of micro-organisms, and it was found to occur chiefly, if not entirely, around the anode.

The Use of Incandescent Lamps in Connection with the Magnetograph.—In a recent number of *La Lumière Electrique* a description is given of the manner in which some small incandescent lamps, made by M. Trouvé, are used to replace the gas and petroleum lamps previously employed in the St. Petersburg Observatory as a source of light in connection with the Adie magnetograph. The necessary current is obtained from Jablochkoff accumulators, and special care has been taken to prevent the magnetic effect of the current disturbing the magnetometers. The advantages of employing incandescent lamps in this connection are briefly as follows:—The curves on the photographic paper are clearer, more uniform, and more sharply defined, consequently they permit of more precision. The substitution of electricity for gas or petroleum causes the troubles due to rise of temperature of the room to disappear. The arrangement is also more economical, and less troublesome to keep in order.

The Royal Alfred Aged Merchant Seamen's Institution.—Telegraphy was well represented at the festival dinner of this

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Institution, which took place at the Hotel Metropole, on Wednesday evening last. Sir James Anderson occupied the chair, and, in the course of his remarks, made reference to his old association with the Cunard line, and was loudly cheered when describing his work on the "Great Eastern," while laying the Atlantic cables. He spoke very feelingly of the hard lot of the sailor, and appealed to his hearers to assist the Institution by providing it with the means of helping the seaman in his old age. The secretary (Mr. W. E. Denny) was able to announce that no less a sum than £4,107. 16s. had been collected, including a subscription of £500 from the chairman. This is a much larger sum than has ever before been announced at the Institution's Festival. Captain Halpin, on behalf of the Committee of the Institution, in thanking Sir James for presiding and for his handsome donation, gave some interesting details of his connection with the cable-laying expeditions referred to. Between 200 and 300 ladies and gentlemen were present, including captains of the cable ships at present at home.

Growth of Electric Lighting in Pittsburgh.—The following table shows the growth of the business of a Westinghouse station owned by the East End Electric Light Company, of Pittsburgh, The business of this Company is largely that of residence lighting, at least 75 per cent. of its lights being of this character :—

——	1886.	1887.	1888.	1889.	1890.
January	82	824	1,725	4,197	11,855
February	170	899	1,735	4,625	12,261
March	225	930	1,753	5,035	13,001
April	290	980	1,801	5,653	14,656
May	310	1,016	1,875	6,917	15,955
June	368	1.080	2,052	7,831	16,632
July	440	1,103	2,120	8,535	17,107
August	500	1,240	2,350	8,867	17,878
September	530	1,361	2,453	9,416	18,242
October	595	1,583	2,696	10,243	19,072
November	622	1,690	3,385	10,968	19,328
December	662	1,703	3,996	11,508	20,134

The Determination of Specific Heats by the Electric Current.—A method of determining specific heats by the electric current was published by Prof. J. Pfaundler in 1869. It depended on Joule's law, and was one in which the same current develops quantities of heat, in coils of wire arranged in series. This method has hitherto found but few applications from the circumstance that it only applies to non-conducting liquids. According to an article in the *Wiener Berichte*, Prof. Pfaundler has got rid of this drawback by substituting for the coils of wire spiral glass tubes filled with mercury. He has also given the method far greater accuracy and certainty by inserting three mercury resistances in the branches of a Wheatstone bridge, by which it is possible to control and keep constant the ratio of the resistances during the passage of the heating-current. Small variations in resistance are compensated by introducing glass threads in the straight ends of the tubes which contained the mercury. In other cases these changes are measured by displacing the contact-key, and in this way the result is corrected. The comparative measurement of the rise of temperature is made more delicate by means of a thermopile.

Hull.—A meeting of the Electric Lighting Committee of the Hull Corporation was held last week. The minutes of the sub-committee appointed to obtain information with regard to the best system of electric lighting recommended that an installation should be laid down by the Corporation on the low-tension three-wire system, and that the mains be laid in culverts, uninsulated. The minutes were discussed at considerable length, and on the motion of the Chairman it was resolved by a large majority to recommend the Council to empower the committee to at once take the necessary steps for laying down such an installation as might be desirable, on the lines of the sub-committee's report, at a cost not exceeding £22,000. Mr. R. E. Crompton, electrical adviser to the Corporation, was in attendance. In his report, he stated that he agreed with the committee that for the town of Hull the low-pressure system was the best one to adopt. In fact, he had seldom seen a town in which it could be carried out so easily and with such great advantage as in Hull. The position proposed for the central station was so well chosen that there was no inducement whatever to adopt the high pressure system with its many dangers and other disadvantages. It is proposed to employ Willans engines and Siemens dynamos.

Postal Telegraph Clerks' Association.—On Saturday last, the tenth annual conference of this Association was held in Edinburgh. There were present 55 delegates. Mr. Thomas Warder (Edinburgh) presided, and said that since the conference was held last year at Leicester several important concessions had been granted by the Postmaster-General, and for these they were grateful, especially for the payment for Sunday duty. Mr. T. D. Venables (Liverpool), secretary, read the annual report, which stated that the progress of the Association was satisfactory. The number of members had increased from 4,578 to 4,648. The Association had gained considerably in strength and energy since the unhappy incidents at Cardiff. The report was adopted. The following resolution was adopted :—"That this conference is of opinion that considerable dissatisfaction still prevails in the service, and that Mr. Raikes's revision has not redressed all the grievances under which we suffered ; and that, moreover, the late scheme presents several anomalies and inequalities." An addition to the motion was adopted, on the suggestion of a Belfast delegate, to the effect that "the number and value of superior appointments in the telegraph branch should be in proportion to the number of clerks employed, and that the proportion should be equal to that enjoyed by the postal branch." The following resolution was then carried :—"That the Dublin resolution shall be rescinded, and that the commencing salary of the general body of provincial telegraphists shall be as at present fixed ; but that the classification of these officers into three classes be abolished, the entire body to consist of one class, and that the annual increment be as at present fixed, and at the end of five years' service the salary be 28s. per week, rising by 2s. 6d. per week until the *maximum* salary be reached, which should be fixed at £200 per annum." The next conference will be held in London.

Bi-Metallic Conductors.—Writing to the *Electrical Review*, of New York, with reference to the Martin bi-metallic conductor and the tests thereof made by Dr. Laisant, Prof. Moses G. Farmer remarks that these gentlemen "ought to know that, on May 30, 1865 (26 years ago), the United States Patent Office granted and issued a patent to Moses G. Farmer and George F. Millekin for a copper conductor having a core or covering of iron or steel. Neither do they seem to know that a half mile of such compound or bi-metallic wire was made in New York by the electro-deposition of copper upon steel in 1868. . . . Neither do they seem to be aware that an ingenious machine was invented and patented by Mr. Alanson Cary, of New York, which would draw a skelp or covering of pure copper upon and over a steel wire, which had been tinned superficially to prevent its rusting, and to aid in soldering the copper to the steel. Nor do they seem to be aware that, by the use of these machines, many hundreds—yea, thousands of miles of wire of this kind were made, put up, and used. . . . Neither do they seem to be aware that a line of telegraph was erected in New Hampshire, in length more than 25 miles, which is still in use. . . . MM. Martin and Laisant seem not to be aware that a wire, which was over $\frac{5}{8}$ths of a mile in length, was stretched across the Mississippi River in 1870, and that it did good service for many months. Also a wire of over 1,200 feet in length did service at the Dudley Observatory for a long time. They do not seem to know that in the earlier eighties many miles of compound, or, if you like it better, bi-metallic wire, were manufactured by the Postal Telegraph Company, working under the patent of the late Luther L. Smith. MM. Martin and Laisant seem not to be aware that about 1,000 miles of this electrolytically deposited wire of sufficient size to offer only one and a-half ohms per mile of resistance were erected between New York and Chicago some dozen years ago, and that communication by telephone was held by means of this wire between the two cities. . . . ."

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MAGNETISM IN IRON AND OTHER METALS.*—XLII.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 125.*)

§ 146. **Tractive Force in Divided Magnets.**—The remarks which have been made in the preceding paragraph may fitly be followed up by a reference to the attraction which subsists between two portions of a magnet when, instead of an imaginary plane of section, we have an actual surface of separation. Let a ring or long bar magnet be cut into portions which have their ends carefully faced to be true planes, and let these abut against one another. The force between the faces may be determined by measuring the amount of pull which is required to draw them asunder.

Measurements of the tractive force between the parts of a divided magnet were made by Joule,† who showed that the amount of the force required to separate two parts of a divided magnet varied as the area of cross-section, and found that the tractive force might be as great as 175lb. per square inch. Shelford Bidwell,‡ using a divided ring electro-magnet of iron,

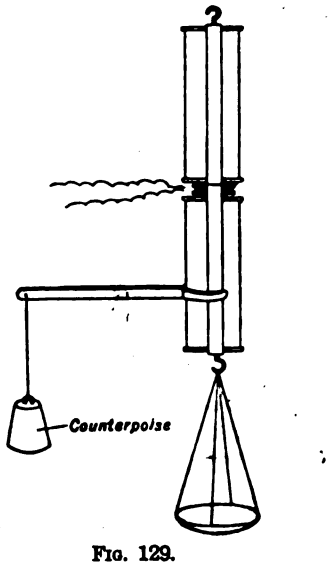

Fig. 129.

found that the weight which could be sustained per square centimetre of the cross-section was related to the magnetising force in the manner shown by Table XXV. :—

Table XXV.—*Tractive Force of a Divided Ring Electro-Magnet.*

Magnetic Force H.	Tractive force in grammes weight per square cm.	Magnetic Force H.	Tractive force in grammes weight per square cm.
3·9	2,210	145	12,800
5·7	3,460	208	13,810
10·3	5,400	293	14,350
17·7	7,530	362	14,740
22·2	8,440	427	15,130
30·2	9,215	465	15,275
40	9,680	503	15,365
78	11,550	557	15,600
115	12,170	585	15,905

As one gramme per square centimetre corresponds to 0·001421b. per square inch, the highest tractive force reached in this experiment was 2261b. per square inch. In these experiments the values of the magnetisation were not directly observed. They may, however, be inferred from the values of the tractive force in a manner which will be explained presently.

Further experiments on the same subject have been made by Bosanquet§, who used bar magnets, and employed a small induction coil (encircling the bar close to the surface of division) to determine the value there of B at the instant the two portions of the bar parted company (Fig. 129). In this case it was possible to compare the actual tractive forces with the values which the forces which were to be anticipated from the known values of B. Bosanquet has made this comparison, and has found a fair agreement except in the early stages of the experiment. When B had any value less than about 5,000 the observed tractive force was greater than the calculated force. This is possibly to be ascribed in part to friction in the appliance by which the lower magnet was guided, and in part to a supplementary attraction between the magnetising coils, which was then more considerable than when B was greater. With an induction B of 18,500 Bosanquet observed a tractive force equivalent to 2071b. weight per square inch of section of his iron core.

§ 147. **Relation of Tractive Force to Magnetisation.**—In connection with these experiments it is interesting to inquire what is the relation that theory would lead us to anticipate between the magnetisation of the core of a rod or ring electro-magnet, and the tractive force necessary to overcome magnetic attraction at the abutting forces if the core is cut in two. This matter has been the subject of some discussion,* and it appears to the writer that a sufficiently careful distinction has not always been drawn between different conditions which, to some extent, affect the result. Consider the case of an indefinitely long rod, or a ring, wound throughout with a solenoid which produces a uniform magnetic force H. Let the intensity of magnetisation be I and the induction B, as usual. Let the rod or ring be cut across, the cut faces be scraped to form true planes, and placed in contact, so that the whole behaves, magnetically, as nearly as possible like an undivided core. At the junction there is an indefinitely narrow crevasse, on each side of which the surface density of magnetism is I. The result of that is (as was shown above in § 145) that the opposing surfaces pull one another together with a stress the amount of which per square centimetre of surface is $2\pi I^2$ in dynes. Since $B = 4\pi I + H$ this quantity may be written $\frac{(B-H)^2}{8\pi}$. If the magnetism that is dealt with is residual (that is to say, if H is zero) this is the whole force that must be overcome in separating the surfaces. So that if s is the area of surface in contact the whole tractive force is in that case equal to $2\pi I^2 s$. But suppose H is not equal to zero, in other words, suppose that some current is circulating in the solenoid, then the separation of the opposing forces involves the movement through a field H in the direction of the field, of a quantity of free magnetism, the amount of which (per centimetre of surface) is I. There is, therefore, a supplementary force required, the value of which is H I.

But this is not necessarily all. The solenoid may itself be wound in two portions—one on each part of the divided core—so that the separation of the core involves the separation of the two parts of the solenoid. In that case we have to exert enough additional tractive force to overcome the attraction of one coil on the other. The amount of the attraction will depend on the area of the coils. Take the simplest possible case, that of a solenoid so closely wound upon the core that the area of the coil may be considered identical with the area of the core. The two coils, considered alone, then behave like magnets having poles whose surface density is $n c$, where n is the number of turns per centimetre, and c is the current. The attraction between them, per sq. cm., is, therefore, $2\pi n^2 c^2$. Since H is equal to $4\pi n c$, this attraction may be written $\frac{H^2}{8\pi}$. We have here a third term which has to be added to the other two in the case considered, namely, when the solenoid (closely wound on the core) is parted along with the core. It must be borne in mind that the second term H I occurs in this case, as well as in the case where the solenoid remains undivided, and the two parts of the core alone part company. For in the case of a divided solenoid each half of the solenoid pulls the opposing half core with a force which, per unit of area, is $2\pi n c$ I, or $\frac{1}{2}$ H I. There are two such forces to be overcome, namely, between the lower core and the upper solenoid, and between the lower solenoid and the upper core, and the two make up H I as before.

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† *Phil. Mag.*, 1852, Vol. III., p. 32, or Reprint of Papers.

‡ *Proc. Roy. Soc.*, 1886, Vol. XL., p. 486.

§ *Phil. Mag.*, 1886, Vol. XXII., p. 535.

* See a Paper by Prof. S. P. Thompson, *Phil. Mag.* 1888, p. 71.

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In the case, then, of a divided electro-magnet, in which the magnetising coil parts along with the core, and in which the coil has no superfluous area (which would add still further to the tractive force), the whole force is made up of three parts— $2\pi I^2 + HI + \frac{H^2}{8\pi}$.

This may be written

$$\frac{1}{8\pi}(16\pi I^2 + 8\pi HI + H^2)$$

$$= \frac{1}{8\pi}(4\pi I + H)^2 = \frac{B^2}{8\pi}.$$

This is the formula commonly used in calculating the relation of the tractive force at the cut to the magnetism. In the exact consideration, however, of any given case, the particular disposition of the magnetising coil should be taken account of. If it is in one length, or carried independently of the core, so that the pull of its two parts on one another does not have to be overcome, the tractive force is less. If, on the other hand, the coil is separated along with the core, and has an area larger than the core itself, the force to be overcome expressed per centimetre of the core will be even greater than $\frac{B^2}{8\pi}$. In practice, especially when dealing with iron, the term expressing the mutual attraction of the magnetising coils is generally insignificantly small, since B is enormous compared with H, for such values of magnetic force as are usually employed.

By considering on general principles the state of stress in a magnetic medium which would give rise to the mechanical forces that are observed, Maxwell* showed that where there is no magnetisation† there is a tension along the lines of force equal to $\frac{H^2}{8\pi}$. Within the indefinitely thin crevasse of air which separates the two opposed faces of a cut magnet there is no magnetisation, and the value of H there is that of B in the substance of the metal. This expression for the tractive force between the faces is therefore equivalent to the expression which has been deduced above in a more elementary fashion, namely, $\frac{B^2}{8\pi}$

§ 148. Determination of Magnetisation by Measuring the Tractive Force.—Once a relationship is established between the tractive force and B or I, measurements of the tractive force may be resorted to as a means of determining magnetisation. This gives a fourth type of magnetic measurements, distinct from the ballistic, the direct magnetometric, and the optical methods which have been described in earlier chapters. The traction method of determining magnetisation has been used with good effect by Bidwell, who determined curves of magnetisation by observing the relation of the tractive force required to separate the halves of a divided iron ring to the intensity of magnetising force produced by a divided solenoid with which the halves of the ring were wound.‡ In reducing the results he used $2\pi I^2 + HI$ as the equivalent of the tractive force. In the actual circumstances of his experiment the addition of the third term $\frac{H^2}{8\pi}$ (making $\frac{B^2}{8\pi}$ in all) would have been proper;§ but the effect of this change on the numerical values of B or of I deduced from his experiments is quite trifling. His magnetic forces ranged up to 585, and producing at their highest value an amount of attraction from which I was calculated to be 1,530, B 19,820, and μ 33·9.‖

More recently Prof. S. P. Thompson has proposed the use of a simple traction-measuring instrument as a workshop appliance for determining permeabilities.¶ This "permeameter," as he terms it, is shown in Fig. 130. The specimen to be tested is a rod which slips through a hole in the top of a substantial iron yoke, and through a bobbin on which the magnetising coil is wound. The lower end of the sample is faced true, and rests on a part of the yoke which is also carefully surfaced. The force required to detach the sample from the surface of the yoke is measured by means of a spring balance. In consideration of the fact that the magnetising coil is left *in situ*, Prof. Thompson takes $\frac{(B-H)^2}{8\pi}$ as the quantity that represents the tractive force, and from this the practical rules are derived:—

$$\text{Pull in lbs.} = \frac{(B-H)^2 \times s \text{ (square centimetres)}}{11{,}183{,}000},$$

or, $$B = 3344\sqrt{\frac{\text{Pull in lbs.}}{s \text{ in sq. cms.}}} + H,$$

or, $$B = 1317\sqrt{\frac{\text{Pull in lbs.}}{s \text{ in sq. inches}}} + H.$$

It appears to the writer that the place chosen for the plane of contact in the "permeameter" is a rather unfortunate one,

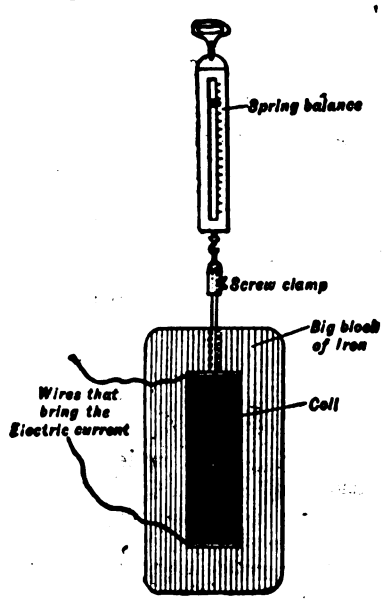

FIG. 130.—The Permeameter.

the distribution of induction being very unequal where the bar meets the yoke, and that better results might be obtained by making the sample in two pieces with a plane of contact at the middle. Apart from this, however, no traction method can be regarded as a very satisfactory means of examining the magnetic quality of a metal. The presence of tensile stress itself affects the quality which is undergoing measurement, and, as will be shown later, a divided rod or ring does not behave magnetically quite like a whole rod, even when the ends are surfaced as carefully as is practicable. The existence of a cut lessens the permeability of the piece.* The traction method is at the best inexact, but it affords a handy means of making rough and ready measurements, especially for purposes of comparison.

(To be continued.)

* Electricity and Magnetism. Vol. ii. §§ 641-646.
† Loc. cit. § 643.
‡ *Proc.* Roy. Soc., 1886, Vol. XL.
§ As Mr. Bidwell has himself remarked, *Phil. Mag.*, 1890, XXIX., p. 440.
‖ To calculate B from the tractive force F we have $B = \sqrt{8\pi F}$, F being expressed in dynes, or

$$B = \sqrt{8\pi \times 981 \times \text{Force in grammes}} = 157\sqrt{\text{Force in grammes}}.$$

This formula will serve to determine B from the values of the tractive force given in Table XXV.
¶ *Jour.* Soc. Arts, Sept. 12, 1890.

ON THE ENERGY CAPABLE OF BEING STORED IN THE MATTER OF SPACE OR ETHER.

BY S. TOLVER PRESTON.

Some calculations of amounts of energy capable of being stored in the matter of space or ether under data, quite possible in practice, may be useful to aid the powers of realisation in view of the direction in which science is advancing.

This matter permeating space is supposed to move in the simplest way, viz.: the movement characterising the kinetic

* *Phil. Mag.*, Sept., 1888.

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theory of gases; and this being the known constitution of the atmosphere, we have one basis of analogy to work upon. Also, as an explanation of gravitation seems to require this movement of matter, the calculations may have some actual interest, in addition to the exercise of the imaginative powers. At any rate, the results will be true, under conditions taken as a basis, which are perfectly possible in nature.

First of all, to calculate how much energy is contained in a grain of matter moving at the velocity of light.* This velocity is, we know, a measured one, of which there is no doubt. The working out of the computation, which is obviously very simple, is not appended, but the result can be readily verified, of course.

(1.) Results are as follows:—

Total energy enclosed in one grain of matter (subdivided into particles or not) moving at the speed of light, is calculably equal to 1,000,000,000 foot-tons, in round numbers.

Or it is equal to the energy possessed by an imaginary cannon ball weighing 40,000 tons, moving at the speed of 1,200 feet per second.

In other words, the work producing power contained in a grain of matter moving at the velocity of light is (calculably) capable of projecting a weight of 100,000 tons to a height of nearly two miles (1·9 miles).

(2.) If the density of the kinetic ether be taken at 1-5 millionth of an atmosphere (only), which represents a "vacuum" so extreme as to be difficult to estimate accurately; then (with a normal velocity of particles equal to that of light) the pressure of the ether would calculably be 500 tons per square inch (about).

(3.) It may be computed that one grain of ether which possesses the above density (1-5 millionth that of the atmosphere) would occupy a cubical space, with side of cube equal to 45ft. Hence (applying our above result), the ether contained in this moderate volume of space has a work-producing power capable of lifting a mass of 1,000,000 tons a height of 1,000ft., which is tantamount to raising a hundred ordinary armour-plated ships to this height (1,000ft.). This illustration is chosen merely to give an idea.

(4.) The energy enclosed in a single cubic foot of space, under these conditions, equals 10,700 foot-tons. Taking the mean velocity of *air* molecules (represented by their normal translatory motion) at 1,600ft. per second: then energy stored in a cubic foot of ether, whose mass represents $\frac{1}{21120}$ of a grain, equals energy of normal translatory motion of molecules of a quarter of a ton of air. This amount of air would occupy a cube with side equal to 41ft.; and the translatory motion of the air molecules, if utilised, would be capable of projecting the air in this cube to a height of about seven miles. So that the energy enclosed in the *air* under the accepted kinetic theory is demonstrably explosive.†

(5.) It may be computed that the energy stored in 2½ cubic feet of space (ether) equals that contained in a railway train weighing 200 tons, moving at 60 miles per hour.

(6.) If—to take another illustration—space were filled with leaden bullets which just graze each other without touching, then the velocity of the bullets (of which space is supposed to be quite full) would require to be, roughly, 1,400ft. per second, or about that, when discharged from an ordinary gun, in order that total sum of energy thus existing in this "rain of lead," so to speak, might equal the energy stored up in the ether in its normal state.

(7.) To afford an idea of relative mass of the ether, taking the above value for ether density, viz., $\frac{1}{1000000}$ of an atmosphere, we may compute that a mass of ether equal to the mass of the sun would be contained within a spherical space of radius which lies a little within Uranus' orbit. This quantity or mass of ether (if the energy of its component particles were entirely utilised) would be capable to give the sun a translatory motion equal to that of light. It would scarcely be believed, perhaps, at first sight that matter so rare as to surpass a good "vacuum," and contained well within the radial limits of the solar system, could enclose an energy competent to give the sun the speed of light, under the assumption that the normal velocity of the ether particles does not exceed this measured unit of velocity. Yet this is seen to be so.

We may calculate in the same way that the mass of ether enclosed within the spherical limits of the solar system itself (the orbit of Neptune) equals, under the above data, four times the sun's mass, *i.e.*, the quantity of matter contained in such a sphere of ether is equal to four times the quantity of matter which forms the sun.

Some might say that calculations as to amounts of energy capable of being stored in space have no definiteness, because we do not know the densities and the velocities of the matter concerned; and by assuming high enough velocity any amount of energy may be conceived stored up.

But first, the essential point to note is that, taking* a known velocity (no greater than that of light) as a basis, then it can be proved definitely that, by a density of matter not surpassing that of a very extreme "vacuum," an energy to the astonishing amount of 10,000 foot-tons can be stored in every *cubic foot* of space, and exerting a pressure of hundreds of tons per square inch. Secondly, it may easily be proved beforehand, that even if such energy did exist, stored in space as an actual physical reality, it would necessarily be concealed from our senses in its normal state; since the higher the normal speed with which particles of matter are endowed, the *less* is the resistance to the passage of objects through such matter, the *more* does the presence of such matter elude ordinary detection, therefore.

These points, with definite calculations as to amounts of energy capable of being stored up under data, by no means impossible or even unlikely in themselves, are the objects that it is sought to illustrate in the present essay.

Is Machinery Mistaken for Source?—A misprint having occurred in my article "The Ether as a Source of Motion," in *The Electrician*, of April 24th, which somewhat obscured the meaning on one point, I would say a few additional words.

It was contended that there was no necessity to wait for absolute confirmation of the (broad) view that coal and oxygen molecules approach each other by ether stresses (heat waves being already proved to be electric) in order to theorise on the system of deriving work.

If work come from the ether, the ether is the source of work obviously, and not the coal. Why has coal come to be commonly regarded as a source of power in itself? I think it must be mainly due to the fact that coal (as a *machine*) is not employed like a normal machine for driving motion from a† source of motion; but the coal is only used once and then

* The velocity of light is here taken in round numbers as 190,000 miles per second. This is a little in excess of the true value, but if the exact value had been taken it would have made no practical difference in our calculations.

† If, therefore, the motion in the atmosphere (that of its molecules) can be explosive in its energy without appealing to our senses, why should not this be possible or easy to conceive in the case of the ether? As *demonstrated* facts are always worth considering, we may further remark that if a piece of ice be held in the hand, we have no particular appreciation of the internal motion therein. But it may be readily calculated from the mechanical equivalent of heat, that the concealed tremors in a piece of ice—which throw the ether into wave motion in all directions—would, if completely utilised, be competent to project the ice to a height of more than 60 miles in opposition to gravity. The motion here imperceptible, but demonstrated to exist (by experiment) is, therefore, more than explosive; *i.e.*, no gun yet invented could project the ice to that height. It is one thing to know a fact, quite another to *realise* it. Without such realisation, the practical lesson is lost in its application to possible realities of nature.

* In order not to clash with observation, it becomes necessary to show, under a dynamical theory, that an adequate ether pressure (consistent with observed ether stresses, "magnetic," "electric," &c.) can exist, without the density of the ether being perceptible.

† It might seem almost a platitude to remark that a source of motion is a source where motion exists. Some might reason in this way at first sight. If the steam be not a source of motion but gets its motion from the coal, if the coal be not a source of motion, but obtains its motion from the ether, where does the ether get its motion from? But the ether *already has* motion in its normal state (an inexhaustible store of motion). The ether is, therefore, the only competent source of motion. But some might object—the coal has motion in its normal state, its heat vibrations. But the energy evidently cannot come from this; for if it did, the heat vibrations of the (molecules of) coal would be *diminished* in communicating motion to engine. But they are increased, on the contrary. The motion obtained cannot be at the expense of the heat vibrations of the coal, therefore; the motion must be derived from a source where motion exists and where no perceptible diminution of the supply is observed, from the fact that the store is practically inexhaustible.

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rejected or thrown away. The reciprocating parts of the machine coal, I would say (or, rather, the collective machine carbon and oxygen) make one stroke and then become useless. It is not so much the question, is there a remedy in this, or in other (larger scale) cases, as a question of recognising* the fact.

It next seems curious at first sight that if the ether be the general source of motion, we can only derive motion from it by expending or rejecting a quantity of machinery proportional to the power derived. This appears an anomalous way of obtaining motion from a source. Can no normal machine for deriving motion from the ether be discovered, *i.e.*, a machine that can be kept in employ, and not be thrown away after having made one stroke?

Now, it is precisely the abnormal way of expending or rejecting machinery in obtaining power from a source (the ether) in quantity proportional to the power derived, which has given us the idea *that the power comes from the machinery itself;* and we have practically lost sight of the source altogether. This seems a truly anomalous or curious state of affairs, whether there be a† remedy or not. I would refer back to the article in question (April 24th) for the additional development of connected points, and venture to suggest that it should be read with the correction five lines from top of second column—"Coal must be regarded as a mere *machine*," instead of (misprinted) "new" *machine*.

Some may say it is too soon to go into these matters. But surely those who reject "action at a distance" can ask themselves what is the true theory of work by its rejection: or it cannot be too soon to do this. In fact, I suppose there are very few who would not now protest if a belief in "action at a distance" were attributed to them.

Prof. Rankine emphasised the notable truth that no law‡ of conservation applies to "force" in the sense of tendency to approach (called "attraction," magnetic, electric, gravitational, &c.), or to a tendency to recede—called "repulsion"—or to any tendency whatever. Conservation applies to *energy* clearly, which (unlike the above tendencies) could not be neutralised or nullified by any conceivable device. Well, one can see the immense importance, at once, or gain to us, in recognising that so-called "forces" are dynamical or material. For in spite of the fact that the neutralisation or nullifying of "force" (in the sense of tendency) by some device, would not be opposed to the conservation of energy; yet we have no control whatever over "force" in the *quasi* spiritual sense attempted to be attached to it (*i.e.*, in the sense of "action at a distance"); we must accept its sway, if once assumed to exist, as a sort of grinding necessity. But, on the other hand, when we realise that tendencies to approach, called "attractions" (or to recede, called "repulsions"), may be due to ether stresses, then we have something under our control, to a certain extent at least. We can manipulate ether, we cannot manipulate (assumed) spiritual "force," so there is no chimera in the *a priori* hope that we may be ultimately able to get work from the ether (which we *do* get now) in a more advantageous way than now, *i.e.*, without* spending work uselessly on the ether, in a manner that can serve no conceivable object whatever.

Without wishing to go into economical questions here, it may just be remarked, in passing, that possibly the keenness of the struggle for existence (in spite of the advance of science and the practical riddance of "action at a distance" by the late discoveries) may be attributed in part to the very expensive methods of deriving motion from the ether at present in use.

Some might consider the above theory of work (illustrated in the article published May 1st and that of April 24th) as very materialistic. The dispute about materialism has been shown to be a mere war of words. If it be meant that there is a show of *necessity* in the doctrine, the contrary may be sustained, for it is the notion of unalterable (spiritual) "force" which constitutes "necessity." We cannot interfere with such "force;" we can, on the other hand, make ether our slave (so to speak). If the ether, for instance, be the source † of the bodily movements, the ether does not direct us, but we direct the ether. These movements depend on the brain (and therefore on the identity or individuality of which the brain is the seat), not on the ether. The ether is no more a director or governor than the steam governs the very elaborate work turned out by some engine constructed by man. "Force," ‡ on the other hand, is the real necessity master; but, fortunately, its days may be said to be numbered in view of the late epoch-making discoveries of Hertz and others,

Ether and Matter.—The assumption of any inherent or fundamental difference between ether and ordinary matter, if gratuitous, certainly tends to check progress.

The publication of the following, written chiefly in answer to two questions, as under, although elementary, may elucidate this point.

(1.) As the ether is imponderable and without mass, how can it do mechanical work?

(2.) In what form is a foot-pound of energy during the time it takes to pass from the sun to the earth?

The reply offered was briefly as follows:—We have no evidence, and, consequently, no right to assume that the ether is essentially different from ordinary matter.

Ordinary matter has *not* the property of "ponderability," at least, we have no evidence for assuming that it has. A piece of cardboard may be said to be "ponderable" towards a vibrating tuning fork § which "attracts" the cardboard. So a portion of matter may be said to be "ponderable" towards the earth which "attracts" it. But this "ponderability" is no more an innate or inherent property of the portion of matter relatively to the earth (‖as far as all evidence goes), than "ponderability" is an inherent property of the cardboard relatively to the attracting fork. So far from there being evidence that gravitation is a "pull," all analogy goes to show that it is a thrust, *a tergo*, the only intelligible effect which can be brought under dynamics. Ponderability, in the sense of an inherent quality, being then abolished by any *dynamical* view or explanation of

* I mean recognising the fact that we are dealing with machinery here, containing within itself no power.

† If there be no remedy in the case of coal, and it would be rash to assert this prematurely, there may perhaps be (query) a resource of some kind in the case of the larger scale electrically charged and magnetic bodies, &c. At any rate, there can be no harm (but only profit) in recognising or discussing the true theory of the subject by the light of recent discoveries, and the tendencies of modern dynamics.

‡ Rankine's words are, viz.: "It is certain that no law of conservation is applicable to the *tendency of a body to change its place*, nor to any mere tendency whatsoever." This paper of Rankine's was called for partly by Faraday's expressed view that the fact of the tendency of a body to approach the earth *varying* as the square of the distance, was opposed to any assumed "conservation of force." Rankine remarks, viz.: "In the case of gravitation the quantity which varies inversely as the square of the distance between a pair of bodies is their tendency to approach each other, to which no law of conservation applies" (*Philosophical Magazine*, April, 1359). It may be observed also that the intensity of "force" (in the sense of tendency) is not constant, but may be variable according to the rate at which the movement of approach, or of recession (separation), of bodies takes place. Thus, if a keeper were pulled away from an electro-magnet at a high velocity (at all an appreciable fraction of the velocity of light), the ether would be notably condensed, as it is an ether stress, and so the "force" required to separate would be greater than under normal conditions (of slow separation). Or if the approach of the keeper were very rapid, the stress would (conversely) be diminished. Hence "force" in the sense of tendency ("attraction" or "repulsion") is a fluctuating quantity, not conserved at all, but conceivably indefinitely changeable, by a constant sum total of energy in the universe. We may observe that, rigidly speaking, reverse processes of approach and separation of bodies are never in both directions equivalent, under the condition of ether stresses, simply because the ether cannot either follow up or yield to the movement (of the body) with a velocity indefinitely great.

* Reference may be made to last article on this point in *The Electrician*, May 1st, p. 14 (also to the number of April 24th).

† The bodily movements are *known* to be derived from or to be at the expense of the oxydation of the food (chemical action). Now, molecules are electrically charged bodies, and if their "chemical" action be an ether stress, the ether is the source of the bodily movements (or the receptacle whence the energy is derived).

‡ I mean "Force" in the sense of a supposed entity which can travel without time. We have the best of reasons for believing that such an entity is a myth. It was conjectured by some only a few years ago that when an electro-magnet was "energised" suddenly, and a "keeper" lay a mile off, something took a flying leap from the magnet to the keeper at such a rate that it jumped "out of time," altogether.

§ The attraction is here, of course, due to the excess of the (normal) air pressure at the back of the cardboard, the air in front being rarefied by the vibrating prong.

‖ Reference may be allowed to my letter "On the Dynamics of Gravity," published in *The Engineer* of April 10th.

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gravity, the ether becomes* like ordinary matter, possessing no more "ponderability" (*as an innate or inherent property*) than ordinary matter does. The idea that ordinary matter possesses distinctively the inherent quality of "ponderability," while, on the other hand, it is assumed that the ether does not, tends, of course, to make the ether appear an abnormal substance where analogies in the reasoning are impossible, and so a distaste for the study of the ether may arise.

As to the foot-pound of wave energy during the eight minutes it takes to pass from the sun to the earth, it would then be in the ordinary form of energy, *i.e.*, doubtless in the form of particles which possess an acceleration of some kind (much in the same way as the particles of air in a wave of sound have an acceleration). In regard to this point, a small calculation made some years ago by me may be briefly mentioned, viz., that the *wave* energy (in heat waves) in a cubic foot of ether next the sun, calculably amounts to 26·8 foot-grains.

Pressures are coming to be recognised as dynamical, generally speaking. The pressure of the air is dynamical, as we know, due to the continual impacts of its molecules. Even so apparently "statical" an affair as the image in a looking-glass is dynamical, or only kept up by the constant impacts of the waves on the surface of the glass, with their reflection to the eye. So there may be no difficulty in realising by analogy that the pressure termed "gravity" is dynamical, although it be as constant as the pressure of the air, or the image in a glass.

ON THE SPEED OF PROPAGATION OF ELECTRIC WAVES IN INSULATING FLUIDS.†

BY L. ARONS AND H. RUBENS.

In one of his first experiments on the production of electric waves, Hertz made use of a square of wire which was interrupted so as to form a sparking place at the middle point of one of its sides. By means of a wire this was connected to one of two electrodes between which an induction coil served to set up very rapid vibrations. At the sparking place small sparks continuously appeared unless the conductor to the square of wire made contact with it at the middle point of the side opposite to that at which the sparking took place. Hertz pointed out that this was an interference point. If a second side of the square was cut and a longer wire inserted between the two ends, the interference point was found to have moved towards the lengthened side; but it was brought back again to its original position by the insertion of an equal length of wire in the opposite side.

The authors adopted this arrangement as a basis, but modified it as follows:—Instead of a square two rectangles of wire, 230cm. long and 35cm. broad, were placed one above the other at a distance of 8cm. One of the corresponding long sides of each rectangle was cut, and four small metal plates, 5·5cm. square, were soldered to the four ends. Over the ends of the wire immediately against the plates were placed small glass tubes, and over these short pieces of brass tube so as to form small Leyden jars, the outer coats of which were connected crossways. From the connecting wires to each pair of coverings wires were carried to the terminals of a bolometer.

The two separate rectangles of wire were further provided with two conductors, which, however, did not lead direct to the coil, but were connected to two metal sheets 8cm. square. These sheets stood at a distance of 3 to 4 cm. from two large primary plates, exactly as in Hertz's apparatus for observing electric oscillations in a stretched wire. The free ends were provided with sliding contacts attached to a vertical wooden rod, and could, therefore, simultaneously be brought into contact with various points along the longer sides of the two rectangles, at positions shown on a horizontal scale.

Since the electric oscillations were now not produced in the wires themselves, but in the space lying between the two rectangles, so that the wires determined only the directions of the waves, the length was altered if some other medium instead of air was placed in this space. The alteration in this length could be determined by the shifting of the interference point, the relation between the length for any particular medium and that for air giving the index of refraction.

One short side of the double rectangle was accordingly placed in a box and insulated therefrom with india-rubber, and carried across in one case in a straight line, and secondly in a zigzag fashion. If p_1 represents the distance of the interference point from zero when the box contained air only and the straight wire was used, p_2 that when the zigzag wire was thrown in instead of the straight one, p_3 and p_4 the corresponding distances when the box was filled with an insulating fluid whose index of refraction was n, we have

$$n \frac{p_4 - p_3}{p_2 - p_1}.$$

In this way the indices of refraction for four fluids were found to be as follows:—

Castor oil	$n = 2·05$
Olive oil	$n = 1·71$
Xylol	$n = 1·50$
Petroleum	$n = 1·40$

The dielectric constants μ for these fluids were also measured by Schiller's method. According to Maxwell $n^2 = \mu$. The results of our measurements were thus:

	μ	$\sqrt{\mu}$	n	Optical index of refraction.
Castor oil	4·67	2·16	2·05	1·48
Olive oil	3·08	1·76	1·71	1·47
Xylol	2·35	1·53	1·50	1·49
Petroleum	2·06	1·44	1·40	1·45

The values found for $\sqrt{\mu}$ and n correspond very well, though they only agree with the optical index of refraction (the D line) in the case of the last two.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

FRIDAY, June 12th.

PHYSICAL SOCIETY OF LONDON.

5 p.m. Papers to be read: (1). "Alternate Current and Potential Difference Analogies in the Methods of Measuring Power." By Prof. W. E. Ayrton and Dr. W. E. Sumpner. (2). "A Clock for Pointing out the Direction of the Earth's Orbital Motion in the Ether." By Prof. O. Lodge, F.R.S. (3). "Some Experiments with Leyden Jars." By Prof. O. Lodge, F.R.S. (4). "The Construction of Non-Inductive Resistances." By Prof. W. E. Ayrton, F.R.S., and T. Mather.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "The Rate of Explosion in Gases." By Prof. Harold Dixon, F.R.S.

WEDNESDAY, June 17th.

ROYAL INSTITUTION.

4 p.m. Faraday Commemoration Lecture. By Lord Rayleigh, F.R.S.

ROYAL METEOROLOGICAL SOCIETY.

7 p.m. Amongst the Papers to be read is the following: "A curious case of Damage by Lightning." By Alfred Hands, F.R.Met.Soc.

ROYAL MICROSCOPICAL SOCIETY.

8 p.m. Ordinary Meeting.

ROYAL SOCIETY.

9 p.m. Conversazione at Burlington House.

SOCIETY OF ARTS.

9 p.m. Conversazione at South Kensington Museum.

CHEMICAL SOCIETY.

8 p.m. Ballot for New Members. Amongst the Papers to be read is the following: "The refractive power of certain Organic Compounds at different Temperatures." By Dr. W. H. Perkin, F.R.S.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

* Without there being any inherent difference in qualities, there may, of course, be dimensional differences between the ether and ordinary matter. Thus, for instance, it is quite possible that the ether may be subdivided into particles very much smaller than those constituting ordinary matter.

† *Wied. Ann.*, Vol. XLII

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THE SCIENTIFIC SOCIETIES.

The general result of the meetings of the scientific societies during the past winter has been very satisfactory, but since the most important Electrical Papers have been divided amongst several different Institutions it is rather difficult to appreciate them as a whole. The progress of electrical engineering, and, perhaps, also the advancement of electrical science, is facilitated by the numerous opportunities which are offered for the reading and discussion of Papers, and the author of any communication has a considerable choice of audiences to choose from. The proper selection of an audience determines to a considerable extent the degree of usefulness of the communication, for not unfrequently the Paper itself is but the raw material for a discussion, and the importance of the latter in so many cases exceeds that of the former, that, if no criticisms, questions, suggestions, rejoinders, explanations, or replies are forthcoming, the Paper, good as it may be, fails to be a landmark, or even an incident, in the progress of knowledge.

We do not intend to review all these Papers, and will allude only to three which the past season has produced on the distribution of electrical energy, the first by Mr. FRANK BAILEY at the Society of Arts, the second by General WEBBER at the Institution of Electrical Engineers, and the third by Mr. CROMPTON at the Institution of Civil Engineers. Nor is it our intention to discuss the relative merits of these three, for they differ so widely in their style and contents that no close comparison is possible. The first of these was, in our opinion, almost thrown away, merely because the discussion was so poor. The Paper consisted of a sketch of the various stations at work in London, so far as the author could obtain information

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about them, a table embodying the chief details, and a collection of very interesting statistics, such as the ratio of maximum lamp supply to the total lamp connection, the proportion of lamps of different candle power, the cost per annum of a lamp at different efficiencies, &c. It is next to impossible to discuss such a Paper on hearing it read, and it is only when the full text and diagrams have been in the hands of members for some days previous to the meeting, that a good discussion can be expected. It happens that it is not the custom of the Society of Arts to afford that facility to its members, and in this case the diagrams were never reproduced at all. General WEBBER'S Paper dealt largely with an ingenious switching arrangement, and with hypothetical efficiencies and probable developments. The few figures from actual practice, relating to the laying of mains elicited a definite rejoinder, but the proofs of the Paper were not circulated thoroughly enough or early enough to allow of a proper study of it before the meeting, and there was a considerable difficulty in inducing members to take part in the proceedings. The third Paper was in some respects of a less practical character than either of those to which we have referred, if the proportion between record of facts and of calculations be considered; but, in accordance with the usual practice of the Institution of Civil Engineers, it had been printed in neat pamphlet form with all the illustrations, and had been sent out to those members and associates who were interested in the subject, the result was that, even a day or two before the Paper was read, a sufficient number of names had been sent in to ensure a discussion extending over two evenings, and, as it turned out, three meetings were devoted to an important debate.

There are some Papers, such as the one on Electric Mining Machinery, which are of so purely an engineering character that even if the authors were members of the Institution of Electrical Engineers they would not be well advised in offering their communication to that body if the older one were open to them; while, on the other hand, such Papers as those on Secondary Batteries could not well be read anywhere than before the Electrical Engineers. There is a prestige about the Institution of Civil Engineers which the younger body cannot expect to rival for many a year, and there is a dignity and deliberation about its proceedings which is worthy of imitation. A Paper submitted to the Civil Engineers is, as in many other societies, carefully considered by the Council, and by no means accepted as a matter of course, but it has only a limited circulation in a proof form, and its publication in full is not permitted until the issue of the volume of the Proceedings. Another custom, which in some cases is a disadvantage, is probably a relic of former days, when the delivery of engineers of the old school was occasionally more full flavoured than intelligible; we refer to the reading of all Papers by the secretary. But these drawbacks are amply compensated by the thorough and liberal manner in which the proofs are sent round, in ample time to allow of a careful perusal of the Paper before the meeting. It is, indeed, possible that the comparative feebleness of the discussions at the Electrical Engineers is due chiefly to the absence of such proofs, or to the irregular and spasmodic manner in which they appear; sometimes without illustrations, or occasionally as a sheet of diagrams with no text. The authors may be to blame for this, but none the less it marks a very important dissimilarity between the two Institutions, and is thoroughly characteristic of the difference between them.

Discussion after a Friday evening discourse at the Royal Institution would be as out of place as at the close of a sermon, and, in many cases, to read a printed copy of the lecture first would rob the hearing of half its charm. But we do not go in for charm at Great George-street, and are content with dry facts. With rare exceptions the facts contained in a Paper, particularly if they are of a solid character, can only be appreciated by quiet study. The reading of such a Paper is a mere matter of form, as is the reading of a Bill before Parliament. The printed copy and the debate are the real matters of importance. The chief advantage offered by the Institution of Electrical Engineers to the authors of the Papers which are presented to it seems to be that the technical press are allowed to reprint the communications in full, if they please, and thus a very wide publicity is given to their contents. In view, therefore, of the utter futility of actually reading the many tabular and mathematical Papers presented, the question naturally presents itself whether, under the circumstances, the reading could not be dispensed with. The author might make a short statement before the opening of the discussion, as is always done at the Civil Engineers; much time, in fact, a whole evening would generally be saved, and a good deal more could be got through in a session. The idea is, perhaps, rather revolutionary, but the conservatism and venerable traditions of the Civil Engineers need have no counterpart in the younger and rather erratic society, which can as easily change its method of procedure as it can alter its name or its habitat. The want of point and frequent dulness of the discussions at the Electrical Engineers seems to arise chiefly from the fact that the mere reading of the Paper, especially if it be an elaborate one, does not put the audience in full possession of its contents, and a discussion started immediately afterwards on the strength of what a few favourably situated members may have heard here and there can very rarely deal with the subject in a useful way.

Defective procedure notwithstanding, the scientific societies and their meetings play a very important part in the development of our knowledge both of electrical engineering and of electrical science. The electrical papers which have been read during the past winter before the Royal Society, the Institution of Civil Engineers, the Institution of Electrical Engineers, the Society of Arts, the Physical Society, and the Society of Chemical Industry, besides the Junior Engineering Society and the Old Students' Association, contain the results of a very large amount of work gratuitously performed by some of the best men of the day, and we may be sure that they will have plenty more to offer when next winter comes round, and they may even find in the meantime something to spare for the advancement of the British Association and its science.

REVIEWS.

Wire: its Manufacture and Uses. By J. BUCKNALL SMITH. Offices of *Engineering*, London. 1891.

One might at first be surprised to find a handsome book of nearly 350 pages devoted entirely to wire, but an examination of the contents shows what a wide subject the author has attempted to deal with. The introductory chapter goes back to 1700 B.C., and, after a brief sketch of the history of wire-drawing, gives a very interesting popular account of some of the innumerable uses to which various kinds of wire are applied. Four chapters in the first section on the manufacture and uses of wire deal with the various kinds of iron and steel, their preparation, physical characteristics, and analyses. An account is given of the different methods of rolling rods, and of drawing the rods into wire, and the various precautions, such as lubrication and annealing, are described very clearly,

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together with the subsequent processes of tempering, galvanising, tinning and coppering. Wire testing and straightening machines are also described in the first chapter. Wires of copper, bronze, silver, &c., their properties and uses, are dealt with rather more briefly in the second chapter, and wire gauges and methods of measuring are discussed in the third.

The fourth and last chapter of the first section is devoted to electrical conductors. Considering the enormous range covered by the subject of wire generally, the space devoted to this branch is, perhaps, fairly proportioned, and the 18 pages of this chapter deal with Matthiessen's standard, resistance of various qualities of copper and iron, the effects of annealing, temperature, density, impurities, &c., on resistance and on sag of telegraph lines. Specifications for telegraph wire, tables of weights, &c., are given, together with a description of the tests made by the Post Office authorities. The second section, on "worked wire, and its applications," is chiefly devoted to the construction and uses of wire ropes, a considerable space being devoted to haulage and mining work. It is hardly possible that this work, which concludes with chapters on wire netting, fencing, and nail making, can thoroughly interest any one individual, but engineers of every branch will find something that concerns them, and probably something that is new to them, in this excellently illustrated and well got up volume.

The Rise and Extension of Submarine Telegraphy. By WILLOUGHBY SMITH. (J. S. Virtue and Co., London. 1891.)

This book is well described in the preface as consisting of jottings set down in chronological order, where possible, of many of the incidents in connection with submarine telegraphy which have come within the personal experience of the author. It has not been his intention to write a complete history of the subject, but in the present volume many interesting details will be found by some future historian, who, while dealing with the subject from a wider and, perhaps, more impartial point of view, must needs make use of such personal experiences as these in compiling a comprehensive treatise on the subject. The manufacture and laying of the first French cable, consisting of 25 knots of No. 14 B.W.G., covered to half an inch with gutta-percha, is given in considerable detail, and the difficulties met with in the construction of numerous important cables are described, and details of several specifications and tests are given. An appendix contains reproductions of "*The Atlantic Telegraph*" issued on board the Great Eastern during the laying of the second Atlantic cable.

Smith's Tables and Memoranda for Mechanics, Engineers, &c. London: Crosby Lockwood and Son. 1891.

This little pocket-book, which has reached its fifth edition, would have been noticed before, but it is so small that it was actually lost in a pocket for a week or so. Although "revised and enlarged," it weighs only a trifle over an ounce. The 16 pages devoted to electrical matters need a little more revision here and there, *e.g.*, it is suggested that there is a Board of Trade rule imposing a limit of 2,000 amperes per square inch. The remaining 242 pages are full of tables that are very useful to engineers. The last two sections are devoted to "Useful suggestions in cases of accident or illness," and to "Knots and splices."

ELECTRIC AND MAGNETIC THEORIES.

BY SILVANUS P. THOMPSON, F.R.S.

(*Concluded from page 133.*)

§ 18. Mr. Sprague has so frankly committed himself to the doctrine that the electric current is propagated in the conducting wire, as water is in a pipe, by end-forces acting longitudinally, that it would seem hopeless to expect him to relinquish his views on this point, however untenable they may prove to be. Before he finally settles himself down into the acceptance of his own views, he must, however, get rid of one most unsettling fact, unsettling that is for those who do not yet grasp the significance of Hertz's experiments, nor comprehend the part played by the medium in the propagation of electric actions. I have already hinted at this fact; I now put it forward as a cardinal point in the controversy. The stream-lines of the flow of an electric current where it spreads out in a sheet or ribbon, and flows past and around some non-conducting obstacle, are of a form wholly distinct from the stream lines of an ordinary fluid propelled past an obstacle of similar shape. Fig. 15 represents the form of the stream lines of an electric current flowing in a strip of tinfoil across the middle of which a small cross-cut has been made as an obstacle. The form of the stream-lines can be experimentally found by first ascertaining, by means of a sensitive galvanometer and a couple of exploring pins connected thereto, the positions of the equipotential lines across the strip; and then drawing the stream lines so as to cross these everywhere orthogonally. It will be noticed that these electric stream lines are symmetrical in front of and behind the obstacle.

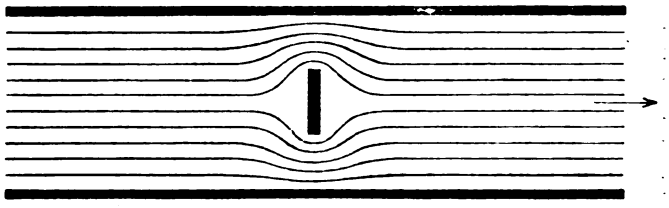

FIG. 15.

In Fig. 16 are shown the stream lines of a real fluid in a narrow channel when passing an obstacle of the same form as in the preceding case. They widen out after passing the obstacle, and set up, as they pass, a couple of swirling eddies in their trail; there being an actual back-wash toward the obstacle down the middle line between the eddies.

Now, it has been shown by Oliver Lodge in the chapter on current phenomena in his book, "Modern Views of Electricity," from which these two figures are taken, that in order to account for this difference between the stream lines of the electric current and those of an actual fluid, we are compelled to accept one of three possible alternatives.

Either (1) there is no friction in the path of the electric current; or (2) there is no inertia in the flow of the electric current; or (3) the propelling force acts at every point of the path; just enough energy arriving at each element of the path to produce in the length of that element a force just sufficient to propel the current against the friction forces existing there.

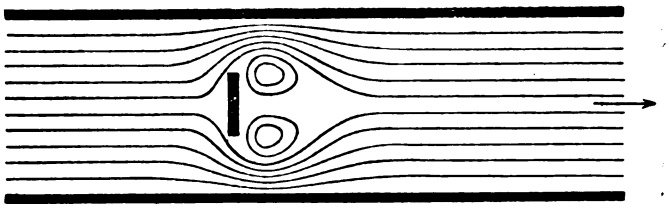

FIG. 16.

I shall be very much surprised indeed if Mr. Sprague sets up the first of these explanations as providing a way out of the difficulty, for if there is one fact on which he can lay stress on his side (and he is entirely welcome to the point) as tending to support the analogy that electricity in a wire behaves like water in a pipe, that fact is that the current heats the wire just as if there were friction in the path. I don't think, therefore, that we shall differ on this point. Secondly, if there is not inertia of the ordinary mechanical sort, there is something uncommonly like inertia in the phenomena of the extra current. It takes time to start or stop a current. It is true that whereas Mr. Sprague locates this phenomenon in the wire, I, as a follower of Maxwell, locate it in the medium outside. Its precise location is not, however, so important an affair as the question whether it exists. If it does not exist, then no argument can be drawn on the matter in question, because then the form of the stream-lines is compatible with either longitudinal end-thrust or with distributive supply of energy at every point. If it exists then the only

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possible conclusion can be that the energy that propels the current is supplied distributively at all points, just as required; and not by end-thrust. If we accept Poynting's deductions from theory as to the flow of energy inwards to the wire from the medium along the intersections of the static and magnetic equipotential surfaces, at every point, as explained in §16, p. 133, then the difficulty about the stream-lines entirely disappears, and leaves the question of inertia undecided either way.

§ 19. Possibly Mr. Sprague, while unwilling to accept Poynting's view about the lateral in-flow of energy across the medium along the equipotential lines, may be prepared to jump at another solution of the difficulty discussed above, and would be ready to accept the third alternative if it could be established without involving lateral transfer of energy. If, in fact, it were possible for the energy to travel longitudinally along the conductor, and yet distribute itself just where required to propel the current against frictional or resistiag forces, he might think less unkindly of the suggestion. Let us, then, try to see what this involves. Perhaps it occurs to someone that, when water is flowing by virtue of gravity down a pipe from a high level to a low one, gravity does not act by an end-thrust exerted on the top, nor yet by an end-pull (or suction) exerted at the bottom, but pulls at each portion of the water in the pipe—in fact, acts distributively. No doubt, so far, this is true: gravity does act distributively on each portion of the water in the pipe, though not by any means in proportion to the resisting forces at every part. But even if the pipe were sloping at an angle, instead of perpendicular, gravity will act on the water inside; and the pull of the earth on the water is certainly not exerted longitudinally along the pipe, though, of course, its resultant will have

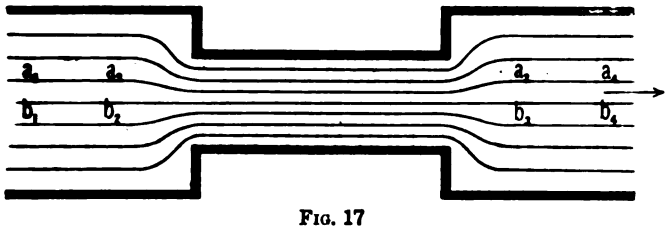
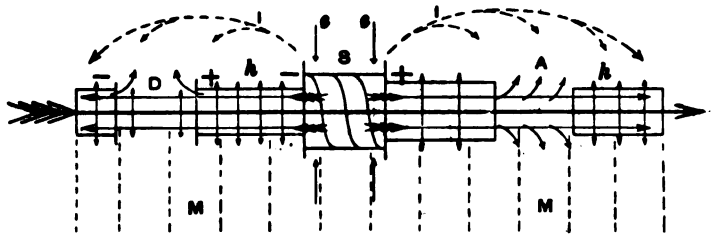


Fig. 17

a longitudinal component. But it is clear that, if at any point the pipe is clogged, or of smaller diameter, so as to offer there a greater resistance than at other parts, gravity does not in any way concentrate itself and exert a greater pull on the water at those parts—it does not distribute itself so as to furnish energy at every point in proportion to the frictional forces at that point. Well, though gravity does not do so in the case of water in a pipe, is it inconceivable that electric forces may do so for the current along a wire? And if they do so, is this mode of action compatible with longtitudinal transfer of energy along the wire? Let us see.

§ 20. Let us consider the case of a conducting circuit of round wire, which is contracted for a portion of its length into a wire of smaller diameter. The stream-lines of an electric current in it will resemble Fig. 17; but as the flat drawing only represents what goes on in one plane, it must be remembered that the stream lines will be similarly contracted in all directions around the axis of the wire. If the thin piece of wire thus interposed be half the diameter of the thicker part, its resistance per unit of length—say per centimetre—will be four times the resistance per centimetre of the thick wire; and as the same current flows through the whole wire, the energy which is expended per centimetre in maintaining it in the thin part is four times as great as that which is expended per centimetre in the thick part. Now, consider any portion of the current in the wire lying between two of the stream-lines as seen in Fig. 17, or rather consider it in the solid rather than in the flat, as a filament of current lying within, and bounded by, a tube of stream-lines lying along its outside, like $a_1\ a_2\ a_3\ a_4$ and $b_1\ b_2\ b_3\ b_4$. The whole current may be considered as made up of such stream-filaments contiguous to one another. Now, if the current is propelled by longitudinal forces, each such stream-filament must be considered as being propelled by forces acting along its own length only, because each stream-filament is virtually independent of the others. So, if each filament is propelled by longitudinal forces acting along its own length, we have this problem to solve: How can forces propagated along the length of a stream-filament distribute themselves along the different parts of that filament in unequal amounts? It is as though we were to have a rope along which forces were being transmitted, which should pull at one part with a force of 11b., then a little further on with a force of 4lb., then, still further on, with a force of 11b. Is it not self-evident that the very way in which the forces are distributed, *unequally* along the stream filament, from point to point, excludes any notion of longitudinal propagation of the energy by a longitudinal push or pull? In facing the actual facts it becomes much more easy to understand how they can be what they are, if we suppose the energy to stream in laterally just as and where it is required, than if we suppose the energy to stream longitudinally along the wire. The difficulties in the way of this latter supposition make it impossible for us, when we consider them carefully, to hold such a view.

§ 21. Mr. Sprague has invited our attention (*The Electrician*, p. 544, March 6, 1891) to a sort of diagram, in which he embodies his views. Current being propagated by end forces longitudinally, he represents an electromotive force by a turbine which drives water into one end of a pipe of variable section, and draws it out at the other end. In this diagram Fig. 2, p. 544 (reproduced), there is some fine confused feeding for the mind. The current is represented by a long arrow from left to right, whilst the energy, which is also considered by Mr. Sprague as a sort of "current inside the conductor," is repre-



sented by four long thin arrows, two of which pass from the + pole of the turbine to the right, and two in the opposite direction from the – pole. What on earth does this mean? Does the energy flow with the current, or does it not? Am I right in taking this to mean that the current sometimes carries energy with it, and sometimes carries the energy in the opposite direction to that in which it is itself flowing? From these energy arrows there branch out sideways some smaller arrows to show how the supplies of energy "proceed" (why not "are transferred")? to carry on the work of heating the resistances and of furnishing heat and light in an arc, A, and chemical action in a voltameter, D. Frankly, I do not understand the voltameter. The current is apparently running in at its negative pole and out at its positive pole, as it would do if it were a battery. It is helping to drive the current, not exercising an opposing electromotive force. Perhaps this accounts for the difficulty about the energy arrows. Some little curved arrows facing inwards from the end-plates of the voltameter doubtless represent the energy spent in driving the current against the electromotive forces of polarisation at the electrodes. Similar curved arrows in the arc apparently represent energy supplied to the arc—nine-tenths of which, by the way, is liberated not in the arc itself but at the surface of its positive crater. Why the curved arrows in these two cases should branch out from the energy arrows, and the cross arrows which represent energy spent in heating the wires should branch out from the current arrow, is an unexplained mystery. Is not the energy that heats the wires equally transferred along the energy paths, or does it only flow in the same direction as the current? Again, there are some dotted arrows, I, outside the wire to represent "the actions which occur in the 'variable period' . . . the static charge or lines of stress existing along the whole circuit and shown in what used to be called the 'tension'

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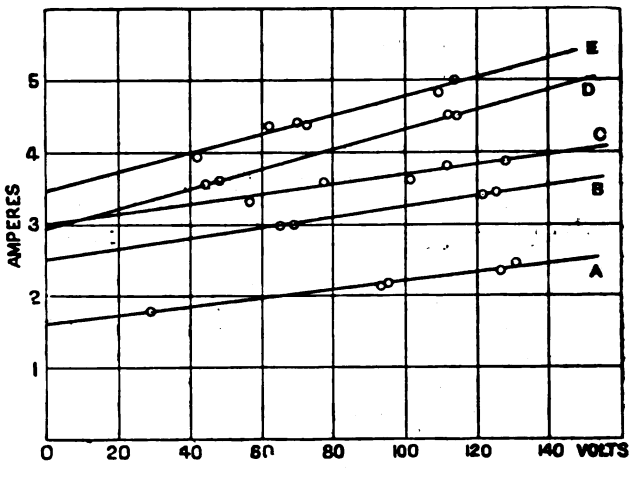
between the various parts, now called slope of potential, &c. This is what is called also the self-induction, inductance, &c." Here, then, Mr. Sprague makes it appear that lines of stress in the medium can branch out of one another—a perfectly new fact in the science, if true. Also, the lines of stress or static charge are "what is called also the self-induction!" Good gracious! what are we coming to? Mr. Sprague knows as well as I do that the slope of potential along a wire depends both on its resistance and on the current through it; and that its self-induction depends on the square of the current, and in no wise on the resistance of the wire, but only on its geometrical outline and the permeability of the surrounding medium. And yet he muddles up the two things and draws one set of arrows to represent them. Moreover, if these arrows suggest anything at all, they suggest that the energy to produce such effects during the variable period flowed from the battery through the medium—and that is not at all what Mr. Sprague is willing to admit. Indeed, he himself says: "This internal stream also supplies the energy necessary for these actions," which he is representing partly by the dotted arrows, I, and partly by the dotted lines, M. Now, if stresses, whether static or magnetic, are to be set up in the medium by energy furnished by the source, why in the name of common sense should not this energy go there direct from the battery, instead of having to run along the wire, sometimes with the current, sometimes against the current, until it comes to the proper place to stream out into the medium to set up the stress? Permit me to put the matter in Mr. Sprague's own peculiar way. How does the energy know whether it is to flow with the current or against the current? How does the energy know how far it must run along the wire before it turns outward into the medium to set up a stress? How does it know, when it gets into the medium outside the wires, in which direction and how far it has to go, and how much stress it is to set up? Or, to quote from Mr. Sprague, the query with which, on p. 576, he crushes all life out of the poor creatures who oppose his views: "How does the external energy distinguish where much or little of it is wanted?" His diagram is an absolute distortion of the facts so far as they relate to the variable period; and it is inconsistent with itself so far as it relates to the facts of the steady flow. It is safe to defy Mr. Sprague to show on any such diagram the simplest experiment of Hertz. Nay, it cannot even represent the facts of the ordinary induction coil. When Mr. Sprague goes on (on p. 609) to explain how it happens that transient currents begin at the surface of the conductor, his arguments become positively amusing. He assumes, in accordance with his Fig. 2, that the energy in the medium always runs along the conductor till it gets far enough, and then streams outwards into the medium to set up a stress. Having assumed, in order to support his views, that energy takes this roundabout way of going to its destination, he then, without proving that it does anything of the kind, goes on to say that "*because* the leakage of energy is from the conductor into outer substances in which a stress is to be set up," and because "current will only be propagated when, and so far as, all stresses are satisfied;" therefore "common sense, without the aid of mathematics, will see at once that this progressive wave of propagation must begin at the surface. . . ." I should have thought that common sense, with or without the aid of mathematics (which is only, after all, a sort of shorthand for common-sense processes of thinking and calculating), would have rather said something like this: Because energy is capable, as we know from the experiments of Hertz, and from experiments on induction coils, of setting up stresses in the medium, and of flowing along the lines of equipotential in the stressed medium, and of setting up electric currents when it arrives at a suitable conductor, and because it reaches the outside of the conductor first before it gets to the inside, therefore the current will start at the outside of the conductor before it starts inside. But no: Hertz's experiments and their logical conclusions appear to be alike thrown away on Mr. Sprague. Great as is his acquaintance with one department of electrical science, and clear as his vision is and has ever been for one set of facts—the chemical facts—he has yet to learn the lesson of the other department in which we have all had so much to learn anew. He is unfortunately under several erroneous impressions. "In fact, the distribution of energy," (he says on p. 730) "by a water current under pressure in a closed pipe, goes on under conditions *absolutely identical*" (the italics are mine) "with those of the electric current." Having said this, he then finds that he must modify the statement in order to account for the external effects in the medium, and so says "we have only to make the conductor elastic," and proceeds to substitute an india-rubber pipe for a rigid steel one. What trifling this all is. Are the copper conductors elastic? Do they swell up or contract in order to produce the effects of surface charge, external magnetic stresses, induction of currents in neighbouring wires, and the like? It is this unfortunate hydraulic analogy which dominates all Mr. Sprague's thoughts, and makes him the slave instead of the master of his arguments. If he could once grasp the real meaning of the difference between the stream lines of the electric current and those of water in a pipe, he would understand how utterly misleading is the idea that the distribution of energy in the two cases is "absolutely identical." I owe much in past years to Mr. Sprague's work; I believe him to have a single-minded desire for truth to grow; I acknowledge how justly he is looked up to by many of the younger race of electricians; I honour his services to the science in the past and in the present. All the more do I deplore his inability to see the significance of a set of facts to which he has given less mature thought; but which no student of the whole science can dare to ignore, or would wish to evade. We cannot ignore or evade the fact that, in the case of variable and periodic currents, the energy which propels the current crosses the medium and enters the conductor laterally, and does not propel the current by end-thrust. And I have shown what good reason we have in the present state of science for coming to the conclusion that in the case of steady flow, also, the energy paths are also across the medium, and not along the wire.

EXPERIMENTS ON FOUCAULT CURRENTS, &c., IN DYNAMOS.

BY R. H. HOUSMAN

The following experiments have been made to test the accuracy of the so-called assumptions on which the validity of the graphic method of analysing armature losses depends:—

Two Chamberlain and Hookham 5-kilowatt dynamos, identical in every respect, running at high speed and low induction



density in the armature (1,440 revs. and B = 12,000), were chosen, so that friction might constitute a large fraction of the total losses measured. The bearings were 1¾in. diameter at the pulley end, and 1¼in. at the commutator end; the commutators were 4in. diameter, with two pair of 1¼in. brushes on each; the armature contained about 3,400cc. of iron in the form of plates ·017in. thick, with about 10 per cent. insulation.

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The two machines were coupled together by a simple flexible coupling, the friction of which was quite negligible. Then, by measuring the power supplied to machine I., the different losses in machine II. were determined by difference with fields excited and unexcited and brushes on and off. Bearing friction of machine II. was determined by difference when coupled and uncoupled to machine I., but in this case a small correction was necessary for the slight vibration caused by the two shafts not being exactly in line. The power wasted from this cause was found to be proportional to the square of the speed, and was represented by ·15 ampere at 120 volts = 18 watts. The loss due to vibration has often been noticed before, especially on a boarded floor with an armature a little out of balance.

The experiments consisted of five distinct sets of measurements—

(A) Machine I., with one pair of brushes only.
(B) Machines I. and II. coupled, only I. excited with one pair of brushes.
(C) Machines I. and II. coupled, only I. excited, four pair of brushes on.
(D) Machines I. and II. coupled, both excited, only one pair of brushes (on I.).
(E) Machines I. and II. coupled, both excited, four pair of brushes on.

It must be observed that the figures deduced for zero volts are those which would be observed if the same law held good right down to zero, as actually does hold from 120 volts to 40 volts, or from 1,440 revs. to 480 revs., which represents about the range of speed used in practice.

Brush Friction (three pairs).

From (C) – (B) at 0 volts	·52	ampere.
From (E) – (D) at 0 volts	·50	„
Mean at 0 volts	·51	„
From (C) – (B) at 120 volts	·45	„
From (E) – (D) at 120 volts	·43	„
Mean at 120 volts	·44	„

Hysteresis and Foucault Currents.

Hysteresis from (D) – (B) at 0 volts	·45	ampere.
Hysteresis from (E) – (C) at 0 volts	·45	„
Mean hysteresis	·45	„

	Amps.
Hysteresis + Foucault currents [from (D) – (B) at 120 volts]	1·22
Hysteresis + Foucault currents [from (E) – (C) at 120 volts]	1·20
Mean hysteresis + Foucault currents, at 120 volts =	1·21

∴ Foucault currents at 120 volts = 1·21 – ·45 = ·76 ampere.

Bearing Friction.

Machine II. from (B) – (A) at 0 volts	= ·88	ampere.
Machine I. from (A) – other losses at 0 volts	= 1·00	„
Mean bearing friction at 0 volts	= ·94	„
Machine II. from (B) – (A) at 120 volts – coupling = 1·06 – ·15	= ·91	„
Machine I. from (A) – other losses at 120 volts	= ·96	„
Mean bearing friction at 120 volts	= ·935	„

The figures for friction of bearings of Machine I. assume that hysteresis and Foucault currents are the same in both machines.

It appears from the above experiments that, within the limits of accuracy attainable in a shop experiment, bearing friction is constant, while brush friction *decreases* as the speed increases.

Bearing friction may be measured approximately without a second motor by running the machine to be tested as a *shunt* motor on very low volts, so that the magnets do not approach saturation. Under these circumstances, as is well known, the speed is independent of the E.M.F. at the terminals, and the power absorbed is almost constant. By calculating for hysteresis and correcting for Foucault currents from the diagram, a very close approximation for the loss in bearing friction may be obtained.

CHIMNEYS AND FLUES.*

In view of the development of heavy electrical engineering it is believed the following notes and formulæ may be found useful by a considerable number of engineers, as this somewhat important subject of chimneys does not appear to be very fully treated in many of the works mostly used in the engineering world :—

Area.

The area depends upon the amount of gases to be delivered and varies inversely as the square root of the height. If

C = weight in lbs. of coal burnt per hour,
A = actual area in square feet,
a = effective ditto,
h = height in feet,
l = length of chimney and flue in feet,
K = a constant depending on size and shape,
k = ditto ditto,
d = diameter in inches of round chimney,
s = side in inches of square chimney,
t_c = temperature Fahr. + 461° of gases in chimney,
t_a = ditto of air outside ditto,
t_{32} = ditto of air at 32° Fahr.,

then

$$a = \frac{C}{17\sqrt{h}},$$

$$A = a + k\sqrt{a},$$

$$C = (A - K\sqrt{A}) \times 17\sqrt{h},$$

$$h = \left[\frac{C}{17(A - K\sqrt{A})}\right]^2,$$

$$d = 13{\cdot}55\sqrt{a} + 4,$$

$$s = 12\sqrt{a} + 4.$$

The actual diameter or side of chimney may be taken as 4 inches greater than the effective size, as the friction of gases against sides of chimney and flue is approximately equal to a layer of air 2 inches thick, and the constants below are calculated on this basis.

K for Round Chimneys	1	feet	diameter	= ·5
„ „ „	3	„	„	= ·55
„ „ „	9	„	„	= ·59
K for square „	1	„	„	= ·55
„ „ „	3	„	„	= ·63
„ „ „	9	„	„	= ·66
k for Round „	1	„	„	= ·74
„ „ „	3	„	„	= ·62
„ „ „	9	„	„	= ·61
k for Square „	1	„	„	= ·83
„ „ „	3	„	„	= ·71
„ „ „	9	„	„	= ·68

Table *of Chimneys, giving capacity in lbs. of Coal per hour.*

Actual Diam. in feet.	Effective area in sq. ft.	Height of Chimney in feet. 60	80	100	125	150	175	200	†Side of Square in feet.
1·0	·35	46	—	—	—	—	—	—	·93
1·5	1·07	141	—	—	—	—	—	—	1·37
2·0	2·18	287	331	—	—	—	—	—	1·81
2·5	3·69	485	561	—	—	—	—	—	2·25
3·0	5·59	735	850	950	—	—	—	—	2·69
3·5	7·85	1,040	1,190	1,340	—	—	—	—	3·13
4·0	10·5	1,390	1,600	1,790	2,000	—	—	—	3·57
4·5	13·6	1,800	2,070	2,320	2,580	2,830	—	—	4·02
5·0	17·1	2,250	2,600	2,810	3,250	3,560	3,860	—	4·47
5·5	20·9	2,760	3,180	3,550	3,960	4,350	4,720	5,010	4·91
6·0	25·2	3,320	3,830	4,290	4,790	5,240	5,690	6,050	5·36
7·0	35·0	4,610	5,320	5,940	6,640	7,290	7,900	8,410	6·24
8·0	46·0	6,080	6,990	7,810	8,730	9,570	10,490	11,100	7·12
9·0	48·5	7,700	8,900	9,950	11,100	12,150	13,200	14,100	7·99

† This represents the actual size of a square chimney having an equivalent effective area.

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The Weight of Gases

delivered by a chimney depends upon the size of chimney and the velocity and density of gases; the velocity being reduced by the friction of gases passing through the fire, and against the sides of flues and chimney. Using the values for these losses, as found by Peclet, where

W = weight of gases delivered per second,

$$W = \cdot0807 \times A \times \frac{493}{t^c}\sqrt{\frac{64\cdot4 \times h \times (t_c - t_a)}{\left(13 + \cdot6\frac{l}{d}\right)t_a}};$$

and for chimneys over 3ft. diameter

$$W = 85\frac{A}{t_c}\sqrt{\frac{h\,(t_c - t_a)}{t_a}} \text{ approximately.}$$

Velocity of Gases.

If v = velocity of gases in feet per second,

$$v = \sqrt{\frac{64\cdot4\ h\,(t_c - t_a)}{\left(13 + \cdot6\,\frac{l}{d}\right)t_a}};$$

and for chimneys over 3ft. diameter,

$$v = 2\cdot14\sqrt{h\,\frac{t_c - t_a}{t_a}} \text{ approximately.}$$

Draught

may be expressed three ways:

1. In pounds per square foot—by the difference between the weight of a column of air of one square foot section and of equivalent height to the chimney at temperature of atmosphere, and the weight of a similar column of hot gas inside the chimney.

If P = draught or pressure in pounds per square foot,

$$P = 39\cdot8\ h\,\frac{t_c - t_a}{t_c \times t_a}.$$

2. In feet of hot gas, or the height in feet by which a column of hot gas of equivalent weight at atmospheric pressure to a column of air at temperature of atmosphere exceeds the height of a column of air of the height of the chimney.

If h = height of chimney,
h_g = height of column of hot gas of equivalent weight at atmospheric pressure,
H = draught in feet of hot gas.

$$H = h_g - h$$
$$= h\,\frac{t_c - t_a}{t_a}.$$

3. In inches of water, by the height of a column of water of equivalent pressure to the pressure P as expressed above.

If H_w = pressure in inches of water,

$$H_w = 7\cdot6\ h \times \frac{t_c - t_a}{t_c \times t_a}.$$

The height of chimney required for a given draught in inches of water is

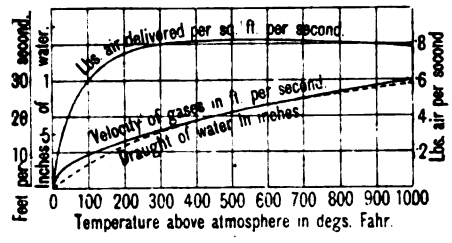
$$h = \frac{H_w}{7\cdot6} \times \frac{t_c \times t_a}{t_c - t_a}$$

$= H_w \times 134$ if temp. of gases is 550° above atmosphere,
$= H_w \times 191$ if temp. of gases is 300° above atmosphere.

The curve given on next column shows the relation between draught, capacity, and velocity of gases in chimneys, from which it will be observed that the capacity is greatest at about 600° F., *i.e.*, between the melting points of lead (630° F.) and bismuth (518° F.). The quantity of air discharged, however, at 600° is only about 4% greater than that at 300° above atmosphere, so that it is desirable where possible to reduce the temperature of the chimney gases by utilising the heat to the lower limit or thereabouts.

The draught giving best results varies with the nature of the fuel used; wood requires least, while slack or fine coal requires most draught. Generally speaking, chimneys should be at least 100ft. high if inferior coal is to be used, though 80ft. or even 60ft. may often be sufficient, where steps are taken for prevention of smoke, or where the settlement of soot in the immediate neighbourhood is not objectionable, and where fairly good coal is used.

The draught varies with the force and direction of the wind and the barometric pressure of the atmosphere, and is regulated by the damper or ashpit door.



Flues should be at least as large as the area of the chimney, and the branch flues should be of at least proportionate effective area, with 2in. added on each side all round for friction. For great lengths of flues it is necessary to increase the size of the chimney either in height or area. For lengths up to 100ft. the loss is practically negligible.

Brick chimneys are far more durable than iron chimneys. The taper, or slope, of a brick chimney should be from $\frac{1}{8}$ to $\frac{1}{4}$in. to the foot on each side. Generally for chimneys over 5ft. internal diameter they should be 1½ bricks thick at top, increasing ½ brick each 25ft. downwards.

Under 5ft. and above 3ft. internal diameter the top should be one brick thick, increasing ½ brick each 25ft. downwards.

Under 3ft. internal diameter the top may be ½ brick for 10ft. from the top, increasing ½ brick each 25ft. downwards after the first 10ft.; though 1 brick at top is always better.

The inside should be lined with firebrick 4½ inches thick to a height of about 15ft. from bottom, an air-space of 1 inch being allowed between the firebrick and main wall of chimney.

A manhole should be constructed either in the base of the chimney or in the flues for admission to the inside. It is better in the chimney, where an arched opening is made which is easily bricked up after using.

Flues should be lined with 4½ inches of firebrick and constructed with as few bends as possible, while sudden alterations in the shape thereof should be avoided. Turns or corners which are unavoidable should be well rounded. Where two flues enter a larger one opposite to each other, unless at an acute angle, there should be in the middle of the larger flue, between the two branch flues, a division or baffle plate or brick wall to obviate the formation of eddy currents. This applies also to chimneys where flues enter the base at opposite sides.

Stability of Chimneys

to withstand wind-pressure varies with the shape of the chimney, together with locality. Messrs. Babcock and Wilcox use the following formulæ:—

If W = weight of chimney in lbs.,*
d = average external breadth in feet,
h = height in feet,
b = breadth of base in feet,
C = constant,

$$b = C\frac{d\,h^2}{W},$$

$$W = C\frac{d\,h^2}{b};$$

where C for square chimneys = 56,
„ octagonal = 35,
„ round = 28.

Hence for the same weight and stability a square chimney requires twice as large a base as a round one. Or for a given base the square chimney requires twice the weight of brickwork for stability. Square chimneys, however, are more durable and less apt to crack than round chimneys.

Roughly speaking, the external diameter of a chimney at the base should be one-tenth of the height.

Iron chimneys should not be less than $\frac{3}{16}$in. thick, and for durability, with most kinds of fuel, double this thickness is

* Brickwork weighs from 100 to 130lbs. per cubic foot.

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preferable. They should be continually painted to protect from rust outside. If lined with fire-brick inside, the lasting power will be greatly increased; the sulphurous gases given off by most fuels attack iron quickly.

Iron chimneys should be either firmly bolted down at the base to a good foundation, or supported by four stays attached to an angle iron ring about one-third the height of the chimney from the top.

Foundations.

It is of utmost importance that the foundation be a good one. Much depends upon the nature of the ground. On solid rock the depth from bottom of flue should be such that the heat will not affect the rock; the depth should also be sufficient to allow for spreading of the base. Where there is no rock the excavation must be carried down to a good foundation on hard clay or sand, which is sometimes not found until 20 to 30ft. down, and occasionally even deeper. It is important, too, that the bed upon which the foundation is laid should be equally solid, or unequal settling may take place. The building should on no account be continued in frosty weather, and, according to Messrs. Bancroft, in very tall shafts the rate of building should not exceed from 2 to 2½ft. per diem, while it is preferable to build tall chimneys in two or more sections, with intervals of several months intervening. The bricks used should be of good quality and of uniform thickness, and should be well soaked before being laid. Mortar should be used in preference to cement, which is attacked by heat, for the lower part of the chimney. Cement is better for the thinner work at the top, especially if 4½in. work be used. Grouting with liquid mortar should on no account be allowed. Ordinary bricks will stand a temperature of 600° F.; above that firebrick must be used.

In tall chimneys the bond should be carefully studied, and it is advisable to have three or four courses of stretchers to one of headers. To obtain additional bond, hoop iron is often built in every few courses. And for chimneys showing signs of weakness, wrought iron straps fixed at intervals round the chimney outside are often used for strengthening.

Chimneys should not be connected with other buildings, and the base of the shaft should be solid to the top of the footings, which should spread on all sides to a projection equal to the thickness of the walls at the base. Fire-brick linings should be independent of the main brickwork.

The Rules of the London County Council require—

Base of square chimneys must be at least one-tenth of the height.
„ octagonal do. one-eleventh do.
„ round do. one-twelfth do.

The batter must be 2½ inches in every 10 feet.

Brickwork not less than 8½ inches thick from top to 20 feet downwards increasing by 4½ inches at least for every 20 feet down.

In many towns in England no chimneys are allowed of a less height than 90 feet.

THE CHEMISTRY OF THE SECONDARY CELL.—A RETROSPECT.

BY G. H. ROBERTSON.

In dealing with the subject of the chemistry of cells of the Planté type, one is struck with how little advance has been made since Messrs. Gladstone and Tribe published their work on the subject in 1882. Then the questions under discussion were local action, the cause of the evolution of gas sometimes observed on first breaking the charging current, the high initial E.M.F., the resuscitating power of the cell—all problems which had been raised by Planté in his "Recherches sur l'Electricité"—and the reducibility of lead sulphate. Turning to recent work, we see nearly the same difficulties still presenting themselves for solution, and, in addition, the question of the temperature changes occurring in the cell has been raised.

Messrs. Gladstone and Tribe found that the sulphating of the peroxide plate due to local action was necessary to the action of the cell, as without it the charge would not be retained long enough to be practically available, and they also pointed out that local action increased with increase of temperature. With reference to the escape of gas, which Planté had attributed to the decomposition of water by local action, they point out that the explanation of local action given by them does not account for the escape of any gas, that the escape of gas is slight and soon ceases, but becomes more pronounced on raising the temperature of the liquid. The gas is oxygen, and heating electrolytic peroxide apart from the lead plate produces an evolution of oxygen, and they further state that testing the liquid between the plates they have always found traces of something which might be ozone or hydrogen peroxide.

Now Planté ("Recherches sur l'Electricité, § 66) noticed the formation of ozone, and observes that a lead voltameter was more favourable to its formation than a platinum, and in §74 he notes the presence of hydrogen dioxide and similar bodies in the acid, and ascribes the high initial E.M.F. to their influence, pointing out that as they are very unstable they are immediately reduced, and unless the discharge takes place at once they will have disappeared. Both Planté (§ 68) and Messrs. Gladstone and Tribe (p. 27) notice the formation of peroxide of lead on the lead plate during discharge, and that a high rate of discharge is favourable to its formation. With reference to its formation, the latter say:—"It is more easy to imagine the peroxide results from the oxidation of the sulphate of lead already formed through the agency of electrolytic oxygen. Hence we get running down of the cell before the peroxide on the peroxide plate is exhausted. On the peroxide plate the peroxide of lead being mixed with a great deal of lead sulphate will suffer decomposition only very slowly through the agency of the supporting plate; but on the lead plate the peroxide is mixed not only with sulphate of lead, but with spongy metallic lead, and will be speedily reduced to sulphate. Hence after rest an apparently run-down cell is found active." In connection with this theory put forward by Messrs. Gladstone and Tribe in 1882, it is interesting to notice the curves exhibited by Mr. Crompton at the Institution of Electrical Engineers in November last (see *The Electrician*, Vol. XXVI., December 12, 1890, p. 175), which show clearly that the higher the rate of discharge the earlier the apparent exhaustion of the cell takes place.

In March, 1883, Frankland (*Proc.* Roy. Soc., Vol. XXXV., pp. 67-70) showed that the occlusion of oxygen and hydrogen had little or nothing to do with the action of the cells, that the state of charge or discharge could be readily estimated by the use of the hydrometer, and put forward the theory that the acid concerned in the interactions occurring in the cell was Bourgoin's* hexabasic sulphuric acid. In the same year, Mr. Preece (*Proc.* Roy. Soc., Vol. XXXV., p. 250) showed that the E.M.F. remains practically constant for all degrees of temperature up to 100°C, but that the internal resistance diminishes as the temperature increases at a very steady rate, increasing again as the temperature is lowered.

Since these early discussions we have had the Paper "On Reversible Lead Batteries," by Mr. Desmond FitzGerald, read at the Institution of Electrical Engineers, March 10, 1887, which dealt chiefly with lithanode cells; Frankland's Paper (*Proc.* Roy. Soc., 1889, 46); and in reply to it Messrs. Gladstone and Hibbert's two Papers (*Phil. Mag.*, August, 1890; January, 1891). Also the two Papers, "The Working Efficiency of Secondary Cells," by Prof. W. E. Ayrton, F.R.S., C. G. Lamb, E. W. Smith, and W. Woods; and "The Chemical Action of Secondary Cells," by Prof. W. E. Ayrton, F.R.S., C. G. Lamb, and E. W. Smith, read before the Institute of Electrical Engineers last year.

Mr. FitzGerald made experiments illustrating the effect lead sulphate has in lowering the E.M.F. of peroxide of lead by mere admixture with it; and in the discussion on the Paper, Prof. S. P. Thompson dealt with a number of the hypotheses, which have been put forward from time to time, as to the chemical reactions occurring in the cell, and working out the E.M.F. of each from the thermal values given by Tscheltzow (*Comptes Rendus*, Vol. C., p. 1,458), showed which were untenable. Frankland's experiments led him to the conclusion that the lead sulphate ordinarily formed in a secondary cell could not be the common irreducible white sulphate hitherto known to chemists, because the active material always remained coloured, even

* Bourgoin, *Comptes Rendus*, Vol. LXIX., p. 890.

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after discharge, and because whenever white sulphate was produced through abnormal reactions, it was with difficulty decomposed. He also concluded that the sudden fall in E.M.F. which takes place towards the end of discharge must proceed from some alteration in the chemical reactions to which the E.M.F. of the cell is due. Frankland therefore tested the action of dilute sulphuric acid on litharge and minium, and obtained bodies of the composition $(SO_3)_3$, PbO_5, and $S_3Pb_3O_{10}$ respectively, which he assumed were oxysulphates, and that their formation took place in the cell, and accounted for the sudden alteration in the E.M.F. In their first Paper Messrs. Gladstone and Hibbert dealt with the body formed by the action of dilute sulphuric acid on litharge, with the action of sodium sulphate in preventing sulphating, and with the question of the high initial E.M.F. of the cell, which they ascribe to the action of the more concentrated action formed during charge in the peroxide plate. In their second Paper they deal with the action of dilute sulphuric acid on minium, and add a note on the action of acid containing sodium sulphate when left in contact with lead for a long time. In neither case did Messrs. Gladstone and Hibbert find any ground for assuming the substance formed by the action of dilute sulphuric acid on litharge or minium respectively to be other than a mixture, but as they made use of analysis their work is open to the objection that they may have destroyed the compound. The other work and the discussion it has given rise to is so recent that it need not be further alluded to, except to say that it is in "The Efficiency of Secondary Cells" that the question of the temperature changes occurring in the cell is raised.

On reviewing the work done in this country since the publication of "The Chemistry of Secondary Batteries," we see that it deals principally with the chemistry of the plates or with physical measurements, and although there have been discussions as to the effect of sodium sulphate there does not appear to have been any attempt made to determine the character of the reactions occurring in the electrolyte itself, though the formation of peroxide bodies in the acid was noticed both by Planté and Messrs. Gladstone and Tribe, and a great deal of work has been done both in this country and abroad on the electrolysis of sulphuric acid solutions.

THE LALANDE BATTERY.

In some recent communications to the Académie des Sciences and to the Société Internationale des Electriciens, M. F. de Lalande, says our Paris correspondent, detailed the various improvements resulting in increased constancy and facility of manipulation which have been made in the construction of his original zinc-caustic potash-oxide of copper cell.

The liquid employed is a 35 per cent. solution of caustic potash, and the oxide of copper plates are now made as follows:—A wet mixture of copper scale and 4 to 5 per cent. of clay is submitted to hydraulic pressure, and baked at a temperature of 600° to 700° C., or the scale may be mixed with 6 to 8 per cent. of tar, and after moulding under pressure placed in a reverberatory furnace. The oxide is in this way reduced, and the whole mass agglomerated. On exposure to the atmosphere the metallic plates oxidise again without change of shape. The plates so obtained are very strong and porous, but poorly conducting. This defect is mainly of importance when the cell first commences working, and to overcome it the agglomerate is "metallised." A layer of powdered zinc is spread over the porous plate, and the whole is plunged into slightly acid water, local action is set up, the zinc dissolves, and the surface of oxide is reduced; but, as it would re-oxidise on drying, an extremely fine film of copper is electro deposited, a large current density of short duration being employed.

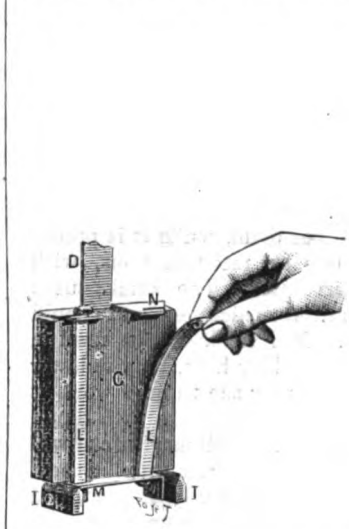

Fig. 1.—Method of mounting the Copper Oxide Agglomerate.

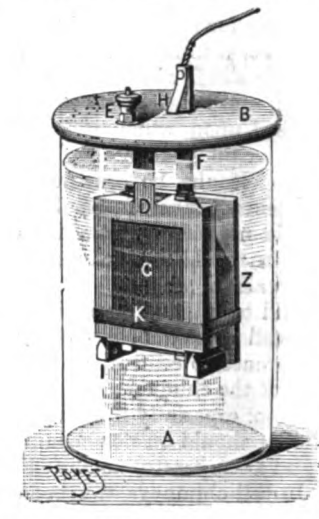

Fig. 2.—Lalande Cell (small size). C, Copper Agglomerate Plate. Z, Zinc Plate. D, Metal Support to Copper Agglomerate. B, Cover. K, Rubber Band. I I, Ebonite Insulators.

The porous plates, C (Fig. 1), are secured against sheet-iron supports, D, by means of springy strips, L L; when they have been completely transformed into metallic copper they are removed, and fresh plates inserted. The old agglomerate plates can be used again after having been washed, roasted and

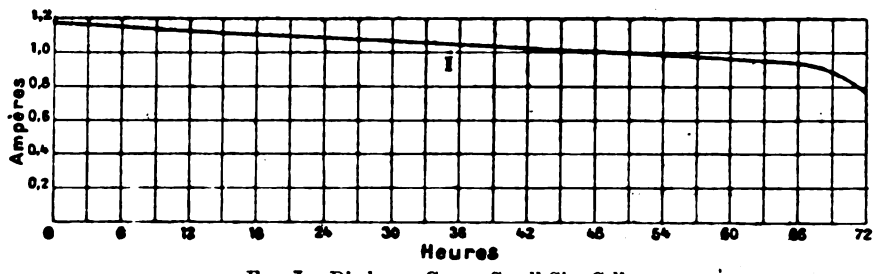

Fig. 3.—Discharge Curve, Small Size Cell.

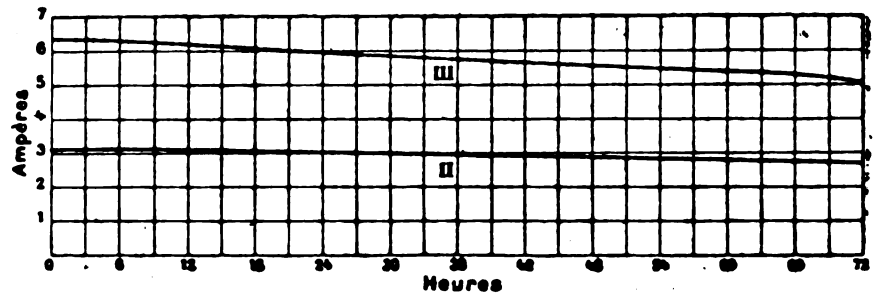

Fig. 4.—Discharge Curve, Medium Size (II.), Large Size (III.)

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"metallised." To prevent the zincs being attacked at the surface of the potash they are entirely submerged in it, being supported from the cover of the cell by tinned iron (Fig. 2). The zincs themselves are also tinned.

The E.M.F. of the cell on open circuit is ·94 volt, and ·8 volt under normal working conditions. Three sizes of cell are made, capable of giving 1·18, 3·25, and 6·4 amperes respectively for long periods, and 4, 12, and 25 amperes respectively for short periods. The capacities of these three sizes of cell are, respectively, 75, 300, and 600 ampere hours, and their average internal resistances ·28, ·07, and ·038 ohm. The discharge curves (Figs. 3 and 4) show the remarkable constancy of this cell.

ANALYSIS OF THE TEMPERATURE COEFFICIENT OF A BATTERY.*

BY PROFESSOR H. S. CARHART.

If the temperature coefficient is a purely thermo-electric effect, then it should be susceptible of analysis by a measurement of the thermo-electric power of the two metal-liquid pairs. If, for example, the thermo-electric power of zinc—zinc sulphate and copper—copper sulphate can be measured separately, then their algebraic difference should represent the temperature coefficient of the Daniell cell, except so far as it may depend upon the thermo-electric power of the liquid pair, zinc sulphate—copper sulphate, which is the only other contact of dissimilar substances in the cell.

So, also, if we combine the results obtained by measuring the thermo-electromotive force of zinc—zinc sulphate and mercury—mercurous sulphate in zinc sulphate, the result should be the temperature coefficient of a Clark standard cell.

§ 1. *To determine the Thermo-Electric Power of Zinc—Zinc Sulphate.*—For this determination it is necessary to have two contacts of zinc, and a solution of its sulphate so related that one can be kept at a constant temperature, while the other is brought to successive different temperatures. Two stout glass tubes, about 4in. (10cm) long and ¾in. in diameter, were connected near the tops by a narrow glass tube, 10in. (25cm.) long. This will be called the "experimental cell." It was filled with zinc sulphate solution saturated at zero, and two zinc wires about a foot in length were suspended so as to dip ½ or ¾in. into the liquid. The immersed ends were slightly amalgamated. Two thermometers were hung from a convenient support, so that their bulbs dipped into the solution at the same depth as the zinc wires. The liquid filling the small tube served to make the electrical connection between the two limbs.

The electromotive force was measured by the following method:—R and R′ in Fig. 1 are two resistance boxes of 10,000 ohms each. For most purposes R′ may be less than 10,000. They must be of the most exact adjustment, or the errors, if any, must be known. They are connected in series with a good Leclanché cell of higher E.M.F. than a standard Clark cell. Two Daniell cells would, perhaps, answer as well, but they are not so convenient.

The total resistance in the circuit must be kept at 10,000 ohms, partly in R, and the remainder in R′. In a derived circuit from A B, the terminals of R are placed in series a Clark cell S C, the experimental cell E C, and the long coil galvanometer G. It is better to include a resistance of 10,000 or 20,000 ohms besides in this circuit. The standard cell must be so connected that its positive is joined to the same terminal as the positive of the main circuit Leclanché cell L C. A key must be placed in both circuits, preferably a double successive contact key of the style used with a Wheatstone's bridge. The first points coming in contact close the main circuit; increased pressure brings the second pair of contact points together, closing the derived circuit. When the pressure is relieved, the derived circuit opens first, and finally the main circuit.

The adjustment consists in changing the resistance in the two boxes, keeping their sum 10,000, till the closing of the circuit does not cause the galvanometer needle to swing. A balance then subsists between the E.M.F. of S C and the fall of potential in the main circuit over the resistance between A and B. The cell E C is not included in the derived circuit in this first balance. The E.M.F. of the standard cell being known, the fall of potential over a single ohm in the main circuit is then known.

The galvanometer employed was a Thomson reflecting instrument, astatic, and having a resistance of 7,000 ohms. A change of a single ohm from R to R′, or the reverse, when the balance is nearly effected, is perfectly evident in the swing of the mirror. In fact, when a balance has been secured, if the key is kept closed for two or three seconds, the polarisation of the main circuit Leclanché cell is always evident in the overthrow of the balance.

The next step is to include the experimental cell in the circuit, as shown in the figure. Both limbs are surrounded with broken ice, and their temperature is nearly or quite the same. It is usually necessary to change the resistance R by a small number of units, perhaps two or three, in order to restore the balance.

One of the limbs is then heated by successive stages, using a bath of warm water. The temperature is allowed to become as nearly stationary as possible, and a balance is again brought about as before. If the resistance R must be increased to bring the galvanometer needle to zero, then the E.M.F. of the experimental cell is so directed as to place the cell in series with the standard cell. If R must be diminished to secure a balance, the experimental cell E C is in opposition to the standard. The closing of the key, therefore, indicates at a glance which pole of E C is positive. For if E C is in series with S C, the galvanometer needle will swing in one direction; if in opposition to S C, it will swing in the other direction; and the direction of the swing always indicates to the operator whether R must be increased or diminished to effect a balance.

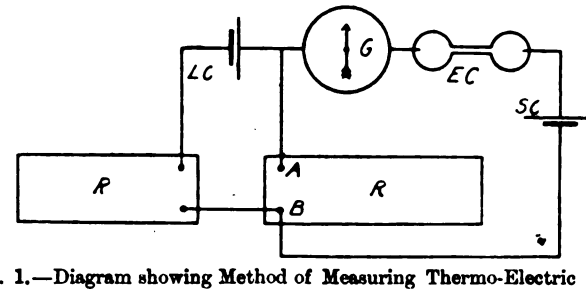

FIG. 1.—Diagram showing Method of Measuring Thermo-Electric Power.

With zinc in zinc sulphate the heating of one limb always produces an E.M.F. tending to make the zinc in the cold the positive plate, or to produce a current *from cold to hot through the cell.* The zinc in the cold limb acts like the zinc of a simple voltaic couple.

The table gives the data of one series of experiments,

Table I.

Temp. C. Left limb.	Temp. C. Right limb.	Temp. difference (corrected).	Resistance in R to balance.	Change in E.M.F. in legal volts.	E.M.F. per degree C.
0·6	0·4	0·2	9141	...	...
9·8	0·4	9·2	9183	0·00660	0·00072
14·4	0·4	13·8	9199	0·00911 ?	0·00065 ?
19·0	0·4	18·4	9225	0·01319	0·00072
27·8	0·4	27·2	9269	0·02011	0·00074
37·6	0·4	37·0	9320	0·02812	0·00076
47·3	0·4	46·7	9377	0·03707	0·00079

The observation marked doubtful I had reason to think included an error in making the balance.

The mean thermo-electric power for a temperature of 23°·85 C. is, therefore, 0·00079.

§ 2. *Thermo-Electric Power of Copper—Copper Sulphate.*—The apparatus was set up in precisely the same manner as before, with a solution of chemically pure copper sulphate of density 1·11. Two freshly electro-plated copper wires were used as electrodes to dip with the thermometers into the solution. The current produced on heating one limb was

* Extract, communicated by the author, from a forthcoming work on "Primary Batteries."

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found to have the same direction as in the case of zinc sulphate, viz., from the cold limb to the warm through the liquid. The copper in the cold acts like the zinc of a simple voltaic cell. The table following contains all the data :—

Table II.

Temp. C Left limb.	Temp. C. Right limb.	Temp. Difference (corrected).	Resistance in R to balance.	Change in E.M.F. in legal volts.	E.M.F. per degree C.
0·6	0·4	0·2	9129	...	...
5·1	0·4	4·5	9145	0·00252	0·00056
9·6	0·4	9·0	9166	0·00582	0·00065
16·1	0·2	15·7	9189	0·00944	0·00060
21·7	0·6	20·9	9216	0·01369	0·00066
32·1	0·5	31·4	9260	0·02061	0·00066
38·4	0·5	37·7	9295	0·02611	0·00069
44·7	0·6	43·9	9330	0·03162	0·00072
49·4	0·6	48·6	9353	0·03524	0·00073

The mean thermo-electric power for the copper—copper sulphate couple is, therefore, 0·00073 for the mean temperature of 25°C. The results for both zinc and copper immersed in their sulphates are plotted in the curves of Fig. 2, in which curve A refers to zinc and zinc sulphate, and curve B to copper and copper sulphate. The total E.M.F.s in legal volts, due to heating one limb are plotted as ordinates, and the differences of temperature as abscissas. It will be noticed that both are slightly concave upward, indicating an increase of the thermo-electric power with rise of temperature.*

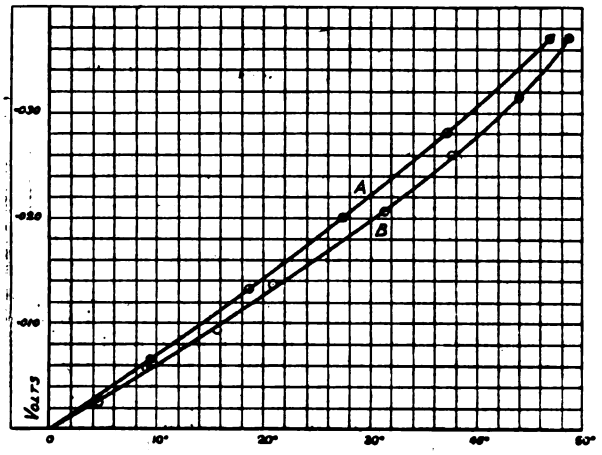

Fig. 2.—Thermo-electric power of $Zn - ZnSO_4$ and $Cu - CuSO_4$.

§ 3. *Application to a Daniell Cell.*—Since both zinc and copper, each in a solution of its sulphate, tend to become negative when heated, or to play the rôle of copper in a simple voltaic element, it is evident that they will exhibit the same phenomenon when set up together as a Daniell cell. When the entire cell is heated, the E.M.F. tends to rise because of the effect at the copper side of the couple, while the heating of the zinc and its sulphate gives to the zinc the power of generating a counter E.M.F. Whether or not the E.M.F. of the cell as a whole will rise or fall with rise of temperature depends upon the relative thermo-electric power at the two sides. The thermo-electric power of $Zn - ZnSO_4$ is a little greater than that of $Cu - CuSO_4$, so that the voltage of the cell falls by a very small coefficient per degree rise of temperature. The near equality of the two thermo-electric powers explains the small temperature coefficient of the Daniell cell.

* Since these experiments were made, the author has ascertained that similar ones were made by Bouty in 1880 (*Journal de Physique*, 1880, p. 229). Bouty made use of a similar method, but employed a Lippmann voltameter for electromotive forces. His results are 0·0006947 and 0·0006885 for zinc and copper in their own salts respectively, expressed as fractions of the E.M.F. of a Daniell. If it is assumed that the Daniell had an E.M.F. of 1·08 volts, the results of M. Bouty are 0·00075 for $Zn - ZnSO_4$, and 0·00074 for $Cu - CuSO_4$. Considering the small electromotive forces to be measured and the many disturbing causes, such as oxidation of the surfaces and convection-currents, the results are in very good agreement.

A little consideration will show that if the $Cu - CuSO_4$ side of a Daniell cell alone is heated, the E.M.F. of the cell will increase, while heating of the $Zn - ZnSO_4$ side alone will cause a somewhat greater decrease of E.M.F. The relative coefficients in the two cases were measured by setting up the experimental cell as a Daniell, making use of the same solutions that were used in the preceding determinations, and inserting in the small connecting tube between the two limbs a plug of purified asbestos to prevent intermixture of the two sulphates. After a balance had been obtained with a Rayleigh standard cell the experimental Daniell was substituted for it. A comparison of the E.M.F. of the two was thus made, and data secured to calculate the changes in the voltage of the Daniell by the subsequent heating. The resistance to balance the Rayleigh cell at 18·7°C. was 9134 ohms. The E.M.F. of the cell at this temperature is 1·434 legal volts. Hence the fall of potential over one ohm is 0·000157 legal volts. This constant is used to calculate changes in E.M.F. of the Daniell under test.

Table III.

Temp. C. $Zn - ZnSO_4$ limb.	Temp. C. $Cu - CuSO_4$ limb.	Corrected temp. difference.	Resistance in R to balance.	Change in E.M.F. in legal volts.	E.M.F. per degree C.
1·0	0·9	0·1	6935	...	...
10·8	0·8	9·9	6896	0·00612	0·00062
18·8	0·9	17·8	6864	0·01115	0·00063
29·6	1·2	28·3	6815	0·01884	0·00067
45·9	1·3	47·5	6709	0·03548	0·00075
1·5	1·8	0·3	6948	...	...
1·4	15·2	13·5	6994	0·00722	0·00053
1·4	26·4	24·7	7036	0·01382	0·00056
2·0	38·8	36·5	7087	0·02182	0·00060
1·4	40·0	38·3	7093	0·02277	0·00059
1·3	48·5	46·9	7129	0·02842	0·00061

The foregoing table of results justifies the anticipation respecting the changes in E.M.F.; for it will be observed that heating the zinc end of the experimental cell causes a marked diminution of the E.M.F., while the opposite result follows the heating of the copper end.

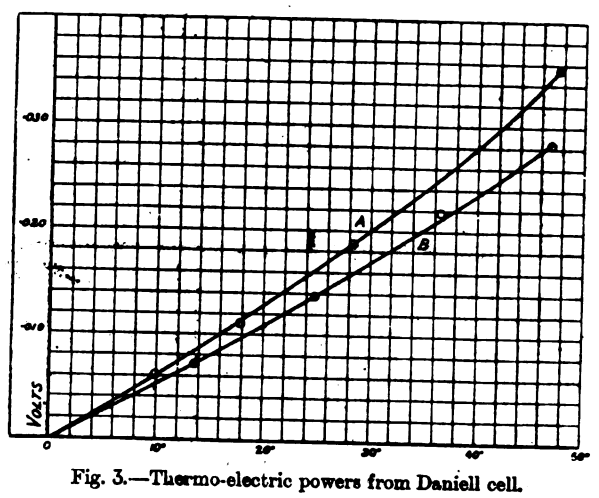

Fig. 3.—Thermo-electric powers from Daniell cell.

The coefficients in this case are both smaller than when each metal in its sulphate was used in both limbs of the cell. The difference is small in the case of zinc, but larger in the case of copper. Another series of measurements, made by heating the copper end of the chain, gave almost identical results.

The changes in E.M.F. resulting from heating one limb are positive, and from heating the other, negative. Both are plotted as positive ordinates in the figure, in order the better to compare them and exhibit the differences. Curve A (Fig. 3) belongs to zinc, and curve B to copper.

§ 4. *Temperature Coefficient of a Daniell Cell.*—A comparison of the thermo-electric powers of Tables I. and II. shows that the resultant effect upon a Daniell cell, due to heating

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the cell as a whole, should be the difference of the two thermo-electric powers, or 0·00079 – 0·00073 = 0·00006 volt per degree, if the effect of heating the junction of the two sulphate solutions is negligible.

To investigate this last question, an experimental cell was made in which the connecting tube was curved so as to include a long U, and the junction of the two sulphates was at the bottom of this U when the cell was set up as a Daniell. After balancing in the usual manner, the U tube was placed in a hot-water bath, by which its temperature was raised from 17deg. to 52deg., or through a range of 35°C. No effect was produced upon the E.M.F. of the cell; or, if any, it was less than one ten-thousandth of a volt for the entire range of 35deg.

Many difficulties were encountered in the attempt to determine directly the temperature coefficient. They appear to be due to small changes in the E.M.F., occasioned by oxidation. The expedient was finally resorted to of setting up the experimental cell as a Daniell with amalgamated zinc and oxidised copper wires, and allowing the apparatus to stand for 15 hours. Consistent results were then obtained with both rising and falling temperatures. The whole cell, except the tops of the tubes, was immersed in water. The following data were obtained :—

Resistance to balance at 16°·8.....	6976	ohms
„ „ 57°·6.....	6956	„
„ „ 15°·2.....	6976	„

A rise of temperature of 48°·4 caused a diminution of 20 ohms to balance, while a fall of 42°·4 increased the requisite resistance 19 ohms. An independent balance with a standard cell gave the fall of potential over a single ohm as 0·0001561 volt. The mean value of the change in voltage per degree was accordingly 0·000073 of a legal volt. This is in very satisfactory agreement with the result calculated from the separate thermo-electric powers.

The E.M.F. of the experimental cell was 1·09 legal volts. Hence the temperature coefficient is 0·000073 ÷ 1·09 = 0·000067. The effect of a change of temperature on the Daniell cell is practically negligible. It is smaller than known disturbances which are assignable to other causes.

§ 5. *Thermo-Electric Power of Mercury—Mercurous Sulphate.*—Some chemically pure mercury was poured into each branch of the experimental cell, and on this was placed neutral mercurous sulphate, free from the mercuric form. Both branches and the thin connecting tube were then filled with a neutral solution of zinc sulphate saturated at 0°C. Connection was made with the mercury in each limb by sealing a long platinum wire into a glass tube, leaving a short portion of the wire exposed at the sealed end. This was pushed down into the mercury on either side.

The cell so set up was then immersed in melting snow and connected in series with the Rayleigh standard, as shown in the diagram, Fig. 1.

By the standard cell the fall of potential over each ohm in R was found to be 0·0001571 of a volt.

One limb of the experimental cell was then heated, while the other was kept at 0°C., with the results shown by the table.

Table IV.

Temp. C left limb.	Temp. C right limb.	Temp. difference.	Resistance in R to balance.	Total E.M.F. in legal volts.	E.M.F. per degree C.
0°	0°	0°	9150	...	...
8·30	0°	8·30	9161	0·00173	0·00021
14·50	0°	14·50	9170	0·00314	0·00022
20·70	0°	20·70	9179	0·00456	0·00022
26·70	0°	26·70	9288·5	0·00605	0·00023
35·80	0°	35·80	9204	0·00833	0·00023
42·60	0°	42·60	9219 ?	0·01053	0·00025 ?
49·25	0°	49·25	9226	0·01163	0·00024

The observation next to the last is marked doubtful because there was reason to suspect an error independently of the failure of this observation to agree graphically with the others.

In Fig. 4 the results are plotted in the curve B, together with those derived from zinc—zinc sulphate. These measurements include, of course, the effect of the contact of the platinum with the mercury, as well as that of $ZnSO_4$ and Hg_2SO_4. But these were purposely included with a view of analysing the temperature coefficient of the Clark cell.

The direction of the E.M.F. produced by heating the $Hg - Hg_2SO_4$ is such as to produce a current through the cell from the cold to the warm limb, precisely as in the preceding cases.

When, therefore, a Clark cell is warmed, there is a tendency to make both poles positive. The effect at the mercury or positive electrode is added to the whole E.M.F. of the cell, while that at the zinc or negative electrode is opposed to the E.M.F. of the cell, as a whole, and must be subtracted. The algebraic

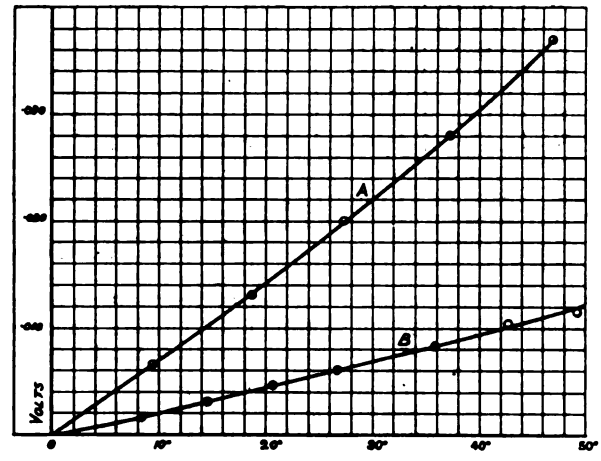

FIG. 4.—Thermo-Electric Power of $Hg - Hg_2SO_4$ and $Zn - ZnSO_4$.

result, then, is the difference of the two thermo-electric powers, and is negative because the $Zn - ZnSO_4$ one is numerically larger than the other. The difference is 0·00079 less 0·00024, or 0·00055.

These are the mean values of the thermo-electric powers. If we apply them to the corresponding equation for the E.M.F. of a Clark cell, involving only the first power of the temperature, we should write

$$E_t = E\,[1 - x\,(t - 15)\,],$$

in which x is to be found. In the writer's cells, with the solution used above, and with the zinc separated from the mercury salt, the E.M.F. is 1·44 true volts at 15°C.

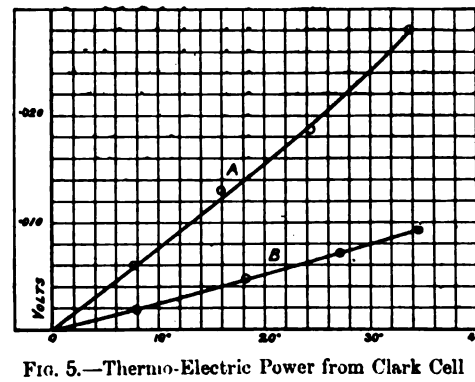

FIG. 5.—Thermo-Electric Power from Clark Cell

Hence $$E_t = 1{\cdot}44\,[1 - x\,(t - 15)\,].$$

If the difference between the thermo-electric powers at the two sides of the cell is the change in volts per degree, then from the preceding equations

$$Ex = 1{\cdot}44x = 0{\cdot}00055.$$

Whence $$x = 0{\cdot}000381.$$

Now, the thermal coefficient of such a cell by direct measurement is 0·000386 at 15°C. The agreement between the two methods is closer even than one might anticipate.

§ 6. *The Experimental Cell as a Clark Cell.*—By simply substituting an amalgamated zinc wire, dipping into the zinc sulphate, for the platinum wire of the last experiment, the experimental cell became a Clark standard. Heating up the

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mercury side alone increased the E.M.F. of the cell; heating the zinc side alone reduced the E.M.F. The results are embodied in the table.

Table V.

Temp. C. $Zn + ZnSO_4$	Temp. C. $Hg + Hg_2SO_4$.	Temp. Difference.	Resistance in R to Balance.	Difference in E.M.F. in Legal Volts.	E.M.F. per Degree C.
15·75	15·8	0·05	9202	...	...
15·80	23·6	7·80	9214	0·00189	0·00024
16·00	34·2	18·20	9232	0·00472	0·00026
16·20	43·2	27·00	9247	0·00708	0·00026
16·25	50·7	34·45	9262	0·00944	0·00027
16·25	15·7	0·55	9207	...	...
23·25	15·7	7·55	9169	0·00598	0·00079
31·60	15·7	15·90	9124·5	0·01298	0·00082
40·00	15·7	24·30	9088	0·01872	0·00077
49·40	15·7	33·70	9029	0·02800	0·00083

The thermo-electric power is in both cases slightly higher than in the experiments on the same metals and their salts separately. But the difference of the mean values is 0·00056 as compared with 0·00055 of the last section. The temperature coefficient of the Clark cell, calculated as before, would be in this case 0·000388. It must be admitted that both of these results differ from the coefficient obtained by the ordinary direct method by a quantity well within the errors of observation.

The curve A of Fig. 5 shows the effect of heating the zinc end alone of the chain, and curve B the mercury end.

All of these curves are slightly concave upward, indicating a small increase of thermo-electric power as the mean temperature increases. Since the mean temperature in this last experiment was 33°, and in the preceding ones on the same metals and metallic salts separately was 24°, the higher values of the thermo-electric power obtained in the present case are partly due to the higher mean temperature.

THE SILVERTOWN PORTABLE TESTING SET.

This is a very compact collection of instruments for testing telegraph, telephone, and electric light circuits, contained in two small wooden boxes, of which one holds the batteries and the other the galvanometer, resistance coils, key, and commutators required for making the two most important measurements on such circuits. For connecting the battery to the testing instruments convenient leads are provided, terminated in brass plugs, with insulated handles for inserting in the proper plug holes. The instruments are connected up together in their own box in such a way as to secure the greatest economy of space, and to enable the two tests to be taken with the greatest readiness. The battery consists of two parts, viz., a set of Leclanché cells of low resistance, intended to be used in testing conductor resistances only; a set of 30 small Leclanché cells, having a total electromotive force of 45—50 volts, intended for measuring insulation resistances or other resistances of considerable magnitude, and subdivided into three sections of 10 cells each. The galvanometer consists of a coil of fine wire on a brass bobbin, in the centre of which a small magnetic needle with an aluminium pointer is hung in the same way as is usual in compasses. The pointer projects through the opening in the end of the coil, and the swing of the needle is limited by the size of the opening to about 45deg. on each side of the centre. The scale, which is a scale of equal currents, is approximately a scale of tangents, and is obtained empirically by calibrating the instrument. On the left-hand side of the box is placed the controlling magnet, which can be made to reduce the sensitiveness by about 40 per cent.

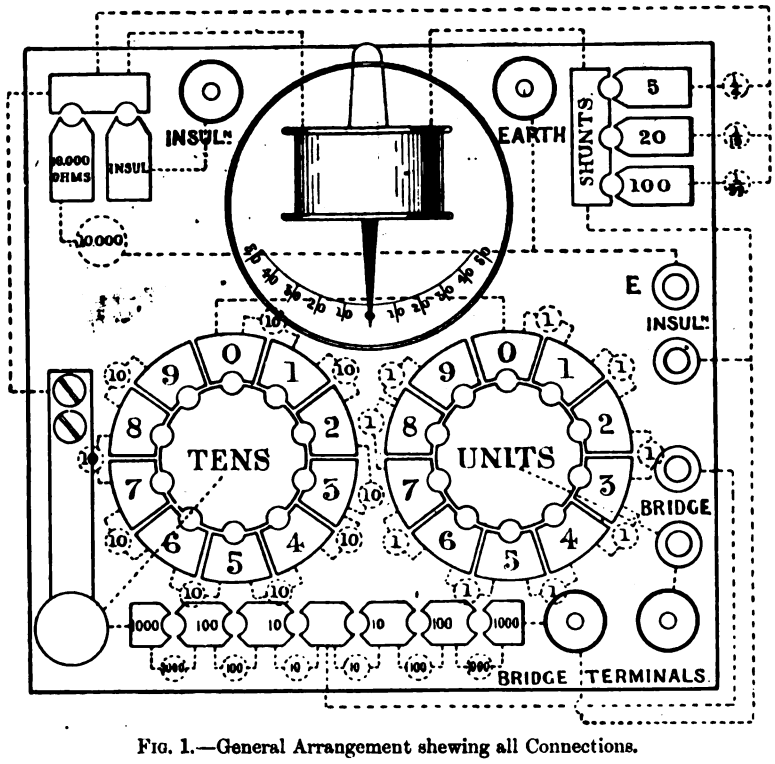

Fig. 1.—General Arrangement shewing all Connections.

Testing Conductor Resistance.—The method used of measuring the resistance of the conductor of the circuit under examination is that of Wheatstone's Bridge. The parts employed are the following:—The adjustable resistance, as will be seen (Fig. 1), consists of two sets of nine coils each connected to circular plug commutators or dials. One set of coils has nine resistances of 10 ohms each, making 90 ohms in all; the other has nine resistances of one ohm each, making nine ohms in all. The second part of the apparatus is the double set of proportional resistances, consisting of two coils of 10 ohms each, two of 100 ohms, and two of 1,000 ohms, these constituting the Bridge. The third part is the galvanometer, which has been already described. Its two terminals are connected to the two ends of the Bridge by depressing the contact key. The battery, as has been already described, consists of four Leclanché cells, having an electromotive force of about six volts.

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The connections are made by inserting the plugs at the ends of the battery leads, in the two holes marked *Bridge*, and immediately this is done the current is established in the coils; the galvanometer circuit is, of course, not completed till the key is depressed. The ends of the conductor to be tested are to be secured under the two terminals marked *Bridge Terminals*, and in measuring low resistances care must be taken that they are very securely attached. Except in testing at the extreme range of the instrument, *i.e.*, quantities less than one ohm or greater than 1,000 ohms, the galvanometer will be found amply sensitive. The battery should be in circuit as short a time as possible, to avoid running down the cells, and it is well to take out one of the battery lead plugs when any alterations are being made in the plug commutators, only replacing it just before pressing the galvanometer key. Care should be taken to connect the conductor to be tested very securely to the bridge terminals. This may be done for very large or stranded conductors either by soldering to their ends thin brass plates with holes in them of a suitable size to go under the heads of the terminals, or the connection may be made by means of finer wires soldered to the ends of the main conductor. The resistance of these must be independently ascertained and subtracted from the gross result.

suppose that a given battery produces on the needle of a galvanometer placed in series with the insulation of a cable in the manner described a deflection of 10·3 divisions, and that on substituting a resistance of one megohm for the insulation we get 42 divisions, we find that the insulation resistance is $\frac{4 \cdot 2}{10 \cdot 3}$ megohms = 4·1 megohms approximately.

The diagram (Fig. 2) shows only those parts of the apparatus and their connections that are used in this measurement; those which relate only to the measurement of conductor resistances being omitted. The arrangement, it will be seen, is as follows: One pole of the battery is connected by a conductor ending in an ebonite-headed plug to the lower of the two plug holes marked *Insul*ⁿ. Thence the current passes along a connecting wire to a block marked *Shunts*, and thence through the galvanometer to the upper block on the other side. From the upper block on the left-hand side the current may take two paths, according as the hole marked *Insul*ⁿ or that marked *10,000 ohms* is plugged; if neither is plugged, the circuit is broken and no current can pass. This plug forms consequently a convenient make and break key. If the hole marked *Insul*ⁿ is plugged, the current passes to the terminal marked *Insul*ⁿ, so through the insulating covering of the cable to the outside sheathing or earth, back to the terminal marked *Earth* and the plug hole

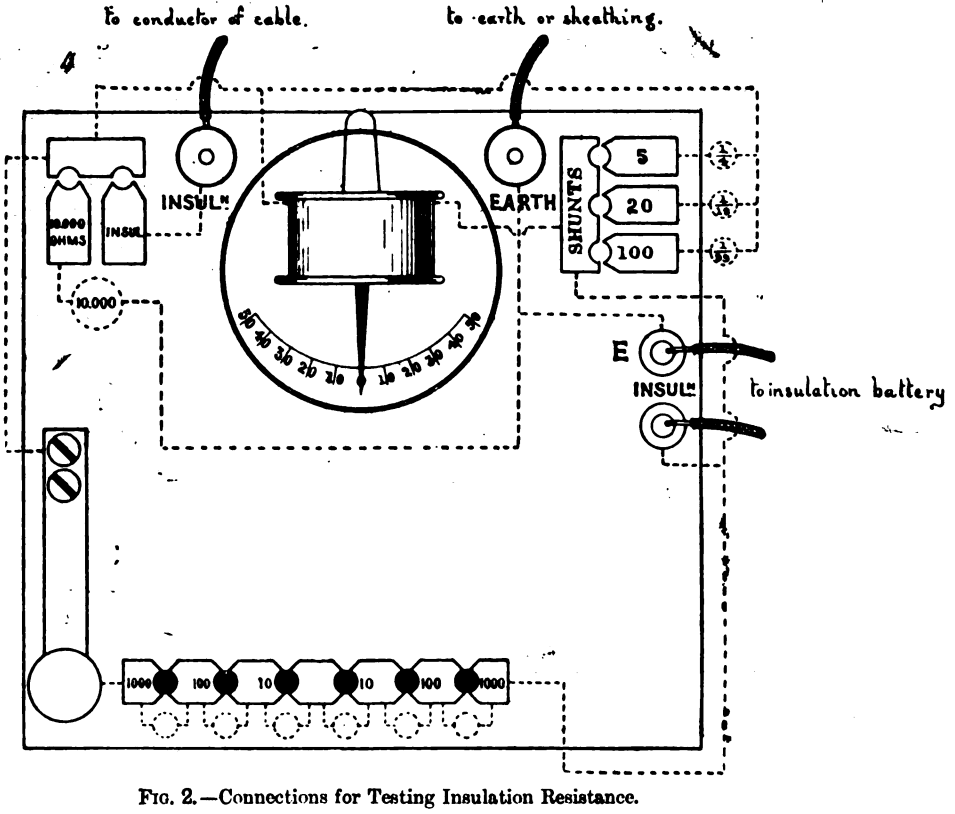

FIG. 2.—Connections for Testing Insulation Resistance.

Measurement of Insulation Resistance.—This is a measurement of the electrical resistance of the insulating material of a cable to the passage of a current from the inside conductor through the insulation to the lead sheathing, wet yarn, armour, or other outside conducting surface, and the inverse of the insulation resistance is the insulation conductivity, or, as it is generally termed, the leakage. This measurement is effected by the method of direct deflections. It consists in passing a current from a battery through a galvanometer into the conductor of a cable whose farther end is free and disconnected, thence through the insulating material to the outside coating or earth, and so back along a temporary conductor to the other end of the battery, the deflection of the galvanometer needle produced by this current being noted. Replacing that part of the circuit which was formed by the insulating material of the cable by a standard resistance of known value, we obtain a new deflection of the galvanometer needle. The quotient obtained by dividing the deflection produced by the current through the standard resistance by that through the cable insulation is a measure of the insulation in terms of the standard. Thus, for example, marked E, and then along the lead to the other pole of the battery. If, however, the hole marked *10,000 ohms* be plugged, the current will pass through a coil of 10,000 ohms, then along a connecting wire to the plughole E, and so back to the battery.

The test, then, consists in:—(1) Noting the deflection obtained when the 10,000 ohm hole is plugged; (2) in transferring the plug to the hole marked *Insul*ⁿ, and again noting. On dividing the deflection on the scale obtained when taking the constant by the deflection obtained in the second part of the test, and multiplying the deflections by the shunt or shunts employed, we obtain the insulation resistance of the cable in megohms.

Terrestrial Magnetism.—One result of the magnetic researches of M. Moureaux and others is to render practically obsolete the old-fashioned magnetic charts with their mathematically regular curves. M. Moureaux is engaged in drawing up charts showing the "isanomel" lines, or curves, passing through the points of maximum abnormality.

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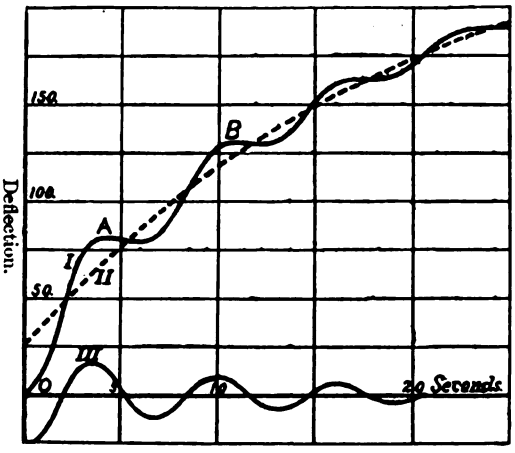
CERTAIN PECULIARITIES IN THE BEHAVIOUR OF A GALVANOMETER WHEN USED WITH THE THERMOPILE.*

BY ERNEST MERRITT, M.E.

When a galvanometer, whose needle is not too thoroughly damped, is used in connection with a thermopile, a curious phenomenon is observed. On suddenly exposing one face of the pile to some source of radiant heat, the needle of the galvanometer moves quickly to one side. In a short time, however, the motion becomes less rapid, and in the course of a few seconds the needle comes to rest, and in many cases moves backward for a short distance. This behaviour is then repeated, and it is only after a long series of such throws, which gradually become less and less marked, that the final steady deflection is reached. The curve O A B in the accompanying figure represents graphically this peculiar motion as observed in the case of a Thomson tripod galvanometer, the abscissa of any point on the curve showing the time that has elapsed since the beginning of the motion, and the corresponding ordinate being proportional to the deflection of the needle from its position of rest. With a galvanometer whose needle is more nearly "dead beat" the maxima and minima, which are so clearly shown in the figure, may not be present; but the general form of the curve will still be the same.

The effect described above was noticed in 1884 by Violle† while using a thermopile to investigate the radiation of molten platinum and silver. Numerous observations of successive maxima and minima are given in his Paper; but no explanation of the phenomenon is offered. Messrs. Rubens and Ritter have observed a similar phenomenon with a peculiar form of bolometer which they used for quantitative measurements of electro-magnetic waves;‡



Curve of the deflections of a Thomson tripod galvanometer in circuit with a thermopile suddenly exposed to source of radiant heat.

and numerous experiments that have been made in the laboratory of Cornell University, with a bolometer of the ordinary type, and with a number of different galvanometers and thermopiles, seem to show that this behaviour is not peculiar to any one instrument, but is always observed when a bolometer or thermopile, in circuit with a galvanometer, is *suddenly* exposed to radiant heat. The writer's attention was first called to the phenomenon in 1888, while engaged in an investigation of the energy of the light from incandescent lamps. In a Paper published during the following year attention was directed to the fact, which at that time rested only upon experimental grounds, that the first throw of the needle, under the circumstances described above, bears a constant ratio to the final deflection, this ratio being independent of the intensity of the radiation to which the pile is exposed.

The phenomenon appears to be due to the inertia of the galvanometer needle, and to the fact that a considerable time elapses after the pile has been exposed to a source of heat, before a constant temperature is reached. On account of its inertia the needle is unable to follow immediately the rapidly increasing current that flows when the face of the pile is first exposed. In a short time, however, the continued action of the deflecting force imparts sufficient velocity to carry it not merely to the position which corresponds to the current then flowing, but to a considerable distance beyond this point. The result is that the motion of the needle is stopped, and a retrograde movement begins, which continues until the pile has been heated sufficiently to cause another throw forward. This behaviour is then repeated until the temperature of the pile has become constant, or until the oscillatory motion of the needle has been destroyed by damping.

On the assumption that the heating of the pile takes place according to Newton's law of cooling, the difference of temperature T, at any instant t, of the two faces of the pile, is related to T_0, the final value of this temperature, by the equation

$$T = T_0 (1 - e^{-kt}) \quad . \quad . \quad . \quad . \quad . \quad . \quad (1),$$

where k is the radiation constant of the surface. The current generated by the pile, and hence the deflecting moment, acting on the needle of the galvanometer, is proportional to T. The writer considers the mathematical theory of the motion of the needle of a damped ballistic galvanometer under the action of such a deflecting couple, and shows that the deflection θ at any moment must be such as to fulfil the equation

$$\theta = T_0 \left[C e^{-kt} \cos \left(\frac{2\pi t}{\tau} + \phi \right) - m e^{-kt} + l \right] \quad . \quad (2)$$

where the constants of the different terms within the bracket are all independent of T_0, the final difference of temperature of the pile.

The motion represented by this equation evidently possesses all the characteristics of that shown in the figure. It may be looked upon as resulting from the combination of two motions, one of them being a steady increase of deflection in accordance with the logarithmic curve represented by the last two terms of the equation, the other a motion of oscillation with gradually diminishing amplitude, as indicated by the first term.

To test the above equation, a series of observations was made with a Thomson tripod galvanometer, every precaution being taken to secure a constant source of heat, and to avoid errors due to draughts of air, magnetic disturbances, &c. The period of vibration of the needle, and its logarithmic decrement (with the thermopile in circuit) were first determined by the ordinary methods. Data for the curve shown in the figure were then obtained by recording on a chronograph the times of the successive maxima and minima, and the time at which the needle passed each tenth division of the scale. Assuming that the equation derived above truly represented the motion, the curve was then analysed into its two components, and after a few trials curves II. and III. of the figure were obtained. These two, when combined, give exactly the motion that was observed, while both are capable of being quite accurately represented by equations of the form indicated in (2). For example, curve II. was found to agree closely with the equation:

$$\theta' = 310 - 283\, \epsilon^{-0.037t},$$

the differences between observed and computed values of θ' in no case exceeding 2 per cent. The time of vibration of the needle, as computed from curve III., was found to be 6·1 seconds, while that observed when the needle was allowed to swing freely was 6·0 seconds. The observed and computed values of the ratio of damping show a similar close agreement, being equal to 1·28 and 1·31 respectively.

The fact, which has already been mentioned, that the first throw of the needle bears a constant ratio to the final deflection, is confirmed by equation (2). Since T_0 is a factor of the right hand member of the equation, and since the expression inside the bracket is independent of T_0, the only effect of a change in the intensity of the source of heat would be to increase or diminish all the ordinates of curve I in the same proportion, the ratio of any two ordinates remaining the same. If, therefore, the final deflection of the needle is proportional to the quantity of heat received by the pile, the first throw will also be proportional to this quantity, and may in all cases be used instead of the final deflection. Experiments made in 1888 to test the above conclusion showed the ratio to be constant for deflections ranging from 100mm to 20mm. The observations have been since repeated, using great care to avoid as far as possible all sources of error, and the following results were obtained as the mean of a number of measurements:—

First throw.	Final deflection.	Ratio.
53·0 mm.	196·0 mm.	0·270
36·5 „	136·7 „	0·265
17·75 „	65·0 „	0·273
5·25 „	19·75 „	0·265

The slight irregular variations which occur might easily be accounted for by the unavoidable errors of observation, especially as the source of heat, an Argand burner, could not be relied upon as perfectly constant. The conclusion that the ratio is independent of the deflection seems, therefore, to be justified, at least in the case of the galvanometer used in these experiments.

The importance of this conclusion will readily be seen by those who have had occasion to use a thermopile for accurate measurements of radiant heat. Draughts of air, and other almost unavoidable sources of temperature variation, frequently make the galvanometer quite unsteady, while the extreme delicacy of the instru-

* From the *American Journal of Science*, Vol. XLI., May, 1891.

† "Sur l'etalon absolu de la lumière." *Annales de Chimie et de Physique*, VI., iii., p. 373.

‡ "Bemerkung zu den Hertz'schen Versuchen über Strahlen electrischer Kraft," *Wied. Ann.*, Vol. XI., p. 63.

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ments that must be used in work of this kind renders them especially susceptible to magnetic disturbances. Many observations are thus made valueless by a change in the zero point of the galvanometer during the three or four minutes required for the needle to come to rest. Only a few seconds are required, however, for the first throw of the needle, and the change in zero point during this time would scarcely ever be sufficient to cause an appreciable error. The use of the first throw in place of the final deflection may therefore lead to greater accuracy as well as to a saving of time.

It will be observed that the principle underlying this method of taking readings is not confined to the case of the thermopile, but is capable of quite wide application, and is of especial advantage when the saving of time is a consideration. A number of experiments which are usually considered unavailable for lecture demonstrations have been quickly and accurately performed in this way under conditions that would render the use of the ordinary method entirely out of the question.

ELECTRIC LIGHTING AT GLASGOW.

At the ordinary monthly meeting of the Glasgow Town Council, on Thursday last week, the minutes of the Gas Committee contained a long report by the special sub-committee on electric lighting. The sub-committee recommended as follows :—

(1). That the Town Council should in the meantime, instead of transferring their powers to any outside person or company, themselves undertake the laying down of the necessary work and plant for generating and supplying electricity for private and public lighting within the compulsory or central area of the city, under such professional advice and superintendence as may be deemed requisite or expedient. (2). That the system of supply, mode of distribution, and other details connected with the proposed installation should, as far as may be found expedient, be in accordance with the reports obtained from Mr. Crompton, Professor Jamieson, and Sir William Thomson. (3). That, if the recommendations now made are approved, the matter be remitted back to the Gas Committee to arrange for acquiring a suitable site for the erection of a central supply station, and to take all other necessary steps for carrying out the proposed works. As will be seen from the report by Mr. Crompton, the cost of putting down the plant requisite for supplying 11,000 16 c.p. lamps (exclusive of cost of sites for central station and sub-station) is estimated at £51,307.

Mr. URE, in moving the adoption of the minutes, explained the recommendations of the committee at length. With regard to the first recommendation, he said a deputation had visited Bradford, and found that there seemed to be in the minds of those whom they met no serious difficulty in the way of a town council carrying on an undertaking such as this. As to the financial results, in the first few months in Bradford they showed a loss of £2,127. In that sum, however, was included £1,086 paid as a sinking fund. The capital expended was about £31,000. During the last six months the loss amounted to £315, and it was expected that in the course of a year the undertaking would be carried on at a profit. The Bradford people commenced selling electricity at fivepence per unit, but they had to raise the price to sixpence. With regard to the second recommendation, Mr. Ure explained that, although the committee had consulted Mr. Crompton, they were not bound to take his system or engage him. If the Council approved of the two first recommendations of the committee they would doubtless adopt the other, and remit to the committee to carry out their recommendations.

Mr. M'LAREN seconded the motion. In company with Mr. Ure, he had had the opportunity, on Monday last, of witnessing the inauguration of the latest installation in London. This installation confirmed his belief as to the wisdom of the recommendation of the committee with regard to the low tension system. All the appliances were the same as those now recommended.

Mr. J. U. PRIMROSE said he had studied all the reports of the committee, and all materials put before the Council. He had read the reports of the various experts, and he was confirmed in the belief that they were only justified in adopting the first of the three recommendations of the Gas Committee. He moved as an amendment that only the first recommendation be accepted. He felt that the Council had not yet emerged from the state of mere experiment, and they had no information put into their hands by experts sufficiently assuring to justify the Corporation in accepting the whole programme recommended to them by the Gas Committee.

Bailie PATON said Mr. Primrose must bear in mind that the sub-committee had spent a large share of time, and a great amount of effort, in getting the information which was now presented to the Council. The conclusion they had come to was one from which in general they would not be easily moved—that was to say, that the three wire low tension system was that which should be adopted in the compulsory area the Council were now asked to deal with. They knew quite well that at present the Council did not want to be committed, nor did the sub-committee wish to be specially committed, to any particular principle of carrying out the work. As to Messrs. Mavor and Coulsen, the sub-committee were not wishful to confiscate any man's property. They were anxious to deal fairly and honourably with Messrs. Mavor and Coulsen.

Mr. PRIMROSE said that, in view of the statement made by Bailie Paton with regard to the spirit dominating the committee, he would withdraw his amendment.

Mr. COLQUHOUN said he was sorry that Mr. Primrose had withdrawn the amendment, which he was just on the point of rising to second. If necessary, he was prepared to move the amendment which Mr. Primrose had abandoned, because he held they were not in a position to go further than affirm the general principle that the Town Council should keep the electric lighting in its own hands. But when the sub-committee asked the Town Council to commit itself to this low-tension system alone, he thought they were taking a course which, with their present information, would not be advisable. What was the position of the Council in this matter? They were bound to provide electric light for the whole city—not merely for the compulsory area. Within the compulsory area they were bound to provide electric light within a period of two years. But the electric lighting order went beyond that, and said that any six ratepayers in any portion of the City could come to the Corporation and demand a supply of electric light. Now, if they were under obligation to supply electric light to, say, six ratepayers in any outlying part of the city, what became of the suggestion that they should have a nice little compact area in the centre, which was to be worked on the low-tension principle? Because what they would undoubtedly have to face in the near future was that they would have a demand from outlying ratepayers. They had received a report from Mr. Crompton, who they knew was a great authority on the low-tension principle. With that report he would find no fault if they were dealing with the compulsory area alone; but that was not the position. Professor Jamieson did not in express terms in any part of his report say that if the whole city of Glasgow were to call upon them to supply electricity the low-tension system was the best. His report was a balancing of the conveniences and inconveniences of the rival systems. He avoided committing himself to what was best for the city as a whole. Sir William Thomson gave as his opinion that for the compulsory district alone the low-tension system was the best. But he had received a statement from Messrs. Mavor and Coulsen, in which he was a little surprised to find certain statements in a report by Sir William Thomson. In this report he found a series of questions put to Sir William Thomson and Sir William's answers. The first question put was this—"Is the system of high-tension distribution, hitherto adopted in Glasgow by this Company, the best for meeting the demand from isolated consumers scattered over a large area?" That was putting in a precise form the question which he (Mr. Colquhoun) would desire to put to Sir William Thomson, and his reply was as follows :—"The system of high-tension distribution hitherto adopted in Glasgow by your Company is the best for meeting the demand from isolated consumers scattered over a large area. No other system hitherto either practised or proposed is adapted to supply this kind of demand." He confessed that he was a little surprised when he found that Mr. Ure, in face of this document, gravely asked the Council to commit themselves to the principle of low-tension alone. He therefore moved that the minute be sent back to the sub-committee for further investigation, and that they should confine themselves to confirming the principle that they should keep the electric light exclusively in their own hands.

Mr. RICHMOND said that the committee who had charge of this matter had done their work well. They had had an enormous amount of labour, and they had given the Council a very good report. At the same time he had some doubt as to whether the recommendation was a safe one. Why should the Council tie their hands now with regard to the outlying districts by adopting this particular system, thereby making it prohibitory for those districts to get a supply?

Mr. URE said that there was no wish to prevent the extension of electric lighting. What they had to deal with just now was exclusively the statutory area.

The Council then divided, when 30 voted for the motion and 7 for the amendment.

LEGAL INTELLIGENCE.

In re the New Telephone Company.

An order has been directed by Mr. Justice North to be made in the matter of this Company, staying winding-up proceedings conditionally on an arrangement by which the debts would be satisfied being carried out.

Mr. Napier Higgins, Q.C., and Mr. Roger Wallace appeared.

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TRADE NOTES AND NOTICES.

[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.]

"THE ELECTRICIAN"

ELECTRICAL TRADES' DIRECTORY & HANDBOOK for 1891.

The 1891 edition of our well-known Directory and Handbook is ready, price 5s., postage extra. The book consists of over 900 pages, and has entailed this year a heavy amount of work. The HANDBOOK DIVISION contains a mass of most useful information. The DIRECTORY DIVISION consists of 430 pages, and contains a very carefully compiled Alphabetical and Classified List of Firms and Persons engaged in the Electrical and Allied Trades in all parts of the world. This Division has been corrected up to date, and the book is thoroughly reliable, the very numerous changes which take place at the beginning of the year being incorporated. By the aid of this Directory, makers of Electrical Machinery, Apparatus, Instruments, Fittings, Sundries, Novelties, and other goods, may safely communicate direct with probable customers without the annoyance and great expense consequent upon using books which are mere lists of Members of Scientific Societies repeated again and again. The Colonial and Foreign Division of this Directory will be found extensive and reliable. *Orders should be forwarded at once.*

On Friday next "The Electrician" Company will publish "THE ELECTRICIAN" PRIMERS in two volumes, price per volume 2s. paper covers, 2s. 6d. cloth.

TENDERS INVITED.—The Caledonian Railway Company invite tenders for the supply of various stores, including crucibles, india-rubber, and telegraph instruments, for 12 months from August 1st next. Specifications may be obtained from Mr. James Lorimer, superintendent of stores, Caledonian Railway, Charles-street, St. Rollox, Glasgow; and tenders must be lodged with the secretary, Mr. John Blackburn, 302, Buchanan-street, Glasgow, not later than Monday, the 22nd inst. Further particulars will be found in our advertisement columns.

——— The Highland Railway Company invite tenders for the supply of various stores, including telegraph instruments and fittings and telegraph construction material, for 12 months from July 1st next. Forms of tender may be obtained from Mr. J. G. Bulmer, storekeeper, Inverness; and tenders must be lodged with Mr. A. Dougall, secretary, Inverness, by the 20th inst.

——— The Lisburn (Ireland) Town Commissioners invite tenders for lighting the town either by electricity or gas. Specification can be seen at the office of the town clerk, Mr. R. Young, Railway-street, Lisburn, and tenders must reach him not later than 12 noon on Saturday (to-morrow).

FOR SALE.—Messrs. Wheatley Kirk, Price, and Goulty announce that they have for disposal the business carried on as Quentin Matsy's Forge, 14, Griffin-street, York-road, Lambeth, London, S.E., together with the machine tools (by Whitworth, Muir, and others), engine and boiler, loose appliances, stock of fancy wrought iron electroliers, &c. Further particulars will be found in our advertisement columns.

MESSRS. BEREND AND CO.—This firm are making some considerable alterations in their establishment, and shortly intend opening a showroom for the display of the various electrical instruments, bronze ware, &c., for which they are agents in this country.

MR. E. S. HINDLEY.—We have received a copy of Mr. Hindley's list, No. 234, which contains illustrated particulars and prices of a number of his well-known manufactures, including horizontal and vertical engines and boilers, donkey feed pumps, fly-wheel steam pumps, circular saw benches, &c. The list can be kept in the pocket, and contains a quantity of useful information.

MESSRS. W. H. WILLCOX AND CO.—This firm announce that they will have on view at the Royal Agricultural Show, to be held at Doncaster, on June 20th, 22nd, 23rd, 24th, 25th, and 26th next, a large selection of engineers' stores, oils, tools, &c.

BATTERY ZINCS.—Messrs. David Moseley and Sons send us a specimen of their new battery zincs, which are composed of a number of sheets of thin zinc, separately amalgamated, and arranged as concentric tubes or as bundles of flat plates. The advantages claimed are that the thin zinc is purer than the ordinary sheets, that the amalgamation penetrates the whole thickness, and that it is found that no cleaning or scraping is necessary. We understand that these zincs have been well tried by some of the telephone companies.

BOOKS, &c., RECEIVED.

"Siemens und Halske auf der Internationalen Elektrotechnischen Ausstellung zu Frankfurt-a.-M., 1891."

"The New General and Mining Telegraph Code." By G. Algernon Moreing, M.I.C.E., and Thomas Neal. (London: William Clowes and Son.)

"The Arithmetic of Electrical Measurements." By W. R. P. Hobbs. (Revised Edition.) (London: Thomas Murby.)

COMPANIES' MEETINGS & REPORTS.

The Anglo-Portuguese Telephone Company (Limited).

The adjourned fourth ordinary general meeting of this Company was held at the offices of the Company, 53, New Broad-street, E.C., yesterday, for the purpose of receiving Directors' report and accounts for 1890, to elect two directors and auditors, and to transact the general business of the Company. Sir Alexander Armstrong, K.C.B., F.R.S., presided.

Mr. R. Rodgers (the Secretary) read the notice calling the meeting, and the report of the Directors was taken as read.

The CHAIRMAN: Gentlemen, in rising to move the adoption of this report, I can do so with very great satisfaction. As you will see, there has been a steady increase of business throughout. The amount to the credit of profit and loss account, after making all reductions, and including the balance brought forward from last year, is £6,193. 15s. 6d. Out of this an interim dividend of 5 per cent. has since been paid, absorbing £2,500, and of the balance it is now proposed to place £2,500 to reserve, and to carry forward £1,193. 15s 6d. to the current year's accounts. I should like to mention, in regard to the reserve fund, that this time last year it stood at £6,000, while it now amounts, with the addition we are making, to the respectable figure of £8,500. The number of paying subscribers up to December 31st has been very satisfactory. At Lisbon there were 1,024, and the gross annual value of them was £7,530. At Oporto the number was 983, of a gross annual value of £5,391, making a total of £12,921, showing an increase in subscribers of 152, and in annual gross value of £1,033 over the preceding year. Now, that was at December 31st, but the account has been since further extended, and I may mention for your information that up to May 31st the total number of the figures is as follows:—At Lisbon 1,085 subscribers, paying an annual income of £7,950, and at Oporto 1,009 subscribers, paying £5,636. The net gross income of the Company up to May 31st is no less than £13,586. It was at the 31st December only £12,921, and it now stands, as I have stated, at £13,586. The increase since December has been 61 subscribers for Lisbon and 26 for Oporto, which had given us in cash £665 up to date—that is, for five months. The average rate of increase is considerably higher than last year, and if it goes on increasing at the same rate to the end of the year, the increase in the number of subscribers will be 210, and an annual income of £1,660. I can hardly fancy, considering the disturbed state of affairs recently in Portugal, and the crisis through which it has passed, that the shareholders will regard the balance as shown in these accounts as other than satisfactory touching the working of the telephone, and I look forward to a very great success now that we have got through the crisis satisfactorily. There has been a little diminution in the payments, but this is cumulative, and they will come out all right in the end, and I think that we may fairly congratulate ourselves and the shareholders upon the satisfactory state of things considering the very disturbed state of Portugal and the bad feeling which existed touching English enterprise. It does not occur to me, gentlemen, that I have anything more to say, and I will simply content myself with moving the adoption of the accounts. I may, however, say that the Directors have the pleasure to announce that Conde De Gouveia and Mr. Pinto Basto have rejoined the Lisbon Board, and that Dr. Marcal Pacheco had been re-appointed the Company's legal adviser in Portugal. So far all matters between the Board in Lisbon and the Board here are in efficient working order. I do not know, gentlemen, that I need do any more than move that the Directors' report and accounts for the year ended December 31, 1890, be received and adopted.

Mr. C. L. W. FITZGERALD seconded the motion.

No questions were asked, and the resolution was at once put and carried.

The CHAIRMAN: I have now to move that Mr. C. L. W. Fitzgerald be, and he is, hereby re-elected a Director of the Company.

Mr. R. VAN ZELLER seconded the motion, which was carried.

The CHAIRMAN then proposed that the Conde De Gouveia should be re-elected a member of the Lisbon Board.

Mr. FITZGERALD seconded the motion, which was carried.

The retiring auditors, Messrs, Deloitte, Dever, Griffiths and Co., were re-elected.

A vote of thanks having been accorded to the Chairman and Directors,

The CHAIRMAN, in reply, expressed the hope that upon the next occasion he would have a very satisfactory account to lay before the shareholders.

The meeting then separated.

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China and Japan Telephone Company (Limited).

The eighth ordinary general meeting of the shareholders of the China and Japan Telephone Company (Limited) was held at the registered office of the Company, 14, Austin Friars, on Tuesday last, for the disposal of the following business: To receive the Directors' report and the audited accounts; to elect a Director in place of the one retiring, but who is eligible for re-election; to appoint auditors for the ensuing year and fix their remuneration; and such other business as might be brought before the meeting. Mr. H. Grewing presided.

Mr. ALEX. B. CHALMERS (the secretary) read the notice calling the meeting, and the report of the Directors was taken as read.

The CHAIRMAN: Gentlemen, I have a few remarks to make in addition to those contained in the report, which we are now asking you to adopt, together with the accounts. The general result when compared with the previous year is rather better. Both revenue and profits on sales have increased, but the net result is only slightly more favourable. The reason is that it had become absolutely necessary for sanitary reasons to remove our exchange at Shanghai from the old quarters to healthier premises, and this has entailed a considerable outlay of close upon £140, which, of course, will not occur again, we hope, for many years, and which has had to come out of the net profit. The long expected opening up of China generally to Western enterprise is still a matter for the future, and we continue to be limited to only two cities in China, which, in point of fact, are the only two cities where it pays to have the telephone introduced, they being the only places which are sufficiently inhabited by European merchants and such as use the telephone. The exchanges at Shanghai and Hong Kong themselves, though very limited in their operations (they are not very large places), are receiving every possible attention both from ourselves and from our managers, and may be said to be capable of some further development. Now, with regard to the balance of net profit shown in the accounts, we have considered it right to recommend that this should be carried forward. There is, in the first place, the question of our debentures to be considered. They are held by the Oriental Telephone Company, and it is true that when, at the end of last year, they became due, they were renewed by that Company, but still only for a further period of five years, and they will become due again at the end of 1895, and we think it prudent, therefore, that some provision should gradually be made in respect to them; and besides that, we have to bear in mind that we may require a further sum, however moderate, in connection with future extensions, and also in order to develop in every way we possibly can the sales business. As there is no capital—no working capital—available, we are of necessity compelled to fall back on the revenue—or upon such part of the revenue as remains available after the expenses are paid. During the year, or rather toward the end of last year, I am sorry to say we lost, by death, our late Chairman, Mr. H.G. Erichsen His loss has been very sincerely regretted by us, as his assistance and advice ever since the formation of the Company has been of the greatest service to us. I think, gentlemen, these are all the observations that I have to make, and I beg to move—

"*That the Directors' report and the audited accounts for the period ended December 31, 1890, be, and the same are hereby, approved and adopted.*"

Mr. LLOYD seconded the motion.

No questions were asked.

The motion was then put, and carried unanimously.

It was then moved by the CHAIRMAN, and seconded by Mr. ADDISON:—

"*That Thomas Lloyd, Esq., be, and he is hereby, re-elected a Director of the Company.*"

The motion was carried.

Mr. LLOYD briefly returned thanks for his re-election.

Mr. H. A. HENTSCH moved, and Mr. J. M. M'LEOD seconded:—

"*That Messrs. Price, Waterhouse, and Co. be, and they are hereby, re-elected Auditors of the Company for the year 1891, and that their remuneration for that period be the sum of 10 guineas.*"

The motion was carried.

Mr. ADDISON moved: –

"*That the sum of 200 guineas be voted to the Directors as remuneration for their services during the past year, such sum to be divided as they may elect.*"

Mr. HENTSCH seconded, and the motion was carried.

The CHAIRMAN, in acknowledging on behalf of himself and colleagues the vote of 200 guineas, said that the interests of the Company would always be in the future, as they had been in the past, their first consideration. There was no further business before the meeting, and he had only to thank the shareholders for their attendance.

A vote of thanks to the Chairman and Directors for their services having been made, the meeting then separated.

Electric and General Investment Company (Limited).

The following is the report of the Directors for the period ending May 31st last, to be presented to the shareholders at the second ordinary general meeting of the Company, at Winchester House, Old Broad-street, on Wednesday, the 17th inst., at three o'clock:—

The Directors beg to submit with this report a statement of the accounts for the period ended May 31, 1891, showing a net profit of £2,592. 6s. 0d. available for distribution, which the Directors recommend should be appropriated as follows:—That a dividend of 10 per cent., together with a bonus of 12s. 6d. per cent., be paid on the capital paid-up on the ordinary shares, that £269. 10s. 9d. be placed to reserve, that a dividend of £1. 5s. 0d. be paid on each founders' share, that £59. 4s. 6d. additional remuneration be paid to the Directors, in accordance with Articles of Association, and that £16. 10s. 9d. be carried forward in equal moieties on account of the ordinary and founders' shares.

A large number of proposals of various kinds have been submitted to the Board, all of which have received careful consideration, and such as seemed suitable for this Company to take up have been fully investigated, but, in view of the great financial depression which has existed for some time past, the Directors have had to proceed with great caution. The Board have now certain important matters in hand, which they have every reason to hope will be successfully dealt with and prove remunerative.

The auditors, Messrs. Rait and Kearton, offer themselves for re-election.

NEW COMPANIES REGISTERED.

ALBERT ELECTRIC LIGHTING COMPANY (LIMITED).—Registered by Bonner, Wright, Thompson, and Co., 165, Fenchurch-street, E.C., with a capital of £10,000, in £5 shares. Object: to carry on the business of electricians, mechanical engineers, &c.

AURORA ELECTRIC LIGHTING AND DISTRIBUTION COMPANY (LIMITED).—Registered by F. Ridley, 52, Leadenhall-street, E.C., with a capital of £25,000, in £1 shares. Object: to establish, carry on, and develop, in the United Kingdom and abroad, the business of an electric light and power company in all its branches.

BIBBY STEAMSHIP COMPANY (LIMITED).—Registered with a capital of £300,000 in £1,000 shares. Objects: to carry on the business of ship owners, ship brokers, insurance brokers, engineers, electricians, &c.

BOURNEMOUTH AND DISTRICT ELECTRIC SUPPLY COMPANY (LIMITED).—Registered by Renshaws, 2, Suffolk-lane, E.C., with a capital of £50,000 in £5 shares. Object: to acquire the right of supplying electricity for light or power, heretofore carried on at Bournemouth by the Brush Electrical Engineering Company (Limited), in accordance with an agreement expressed to be made between the Brush Electrical Company of the one part and the Company of the other part, and to carry on the business of electrical engineering in all its branches. There shall not be less than three nor more than seven Directors. The first are John Fair, William Fisher, D. M. Fox, J. Atkinson Hosker, G. J. Piercy, A. H. Sanderson, and L. Scarth. Qualification, 20 shares. Remuneration to be determined in general meeting.

COMMERCIAL CONTRACT CORPORATION (LIMITED).—Registered with a capital of £50,000 in £1 shares. Among the objects are the manufacturing and dealing in any machinery or apparatus for the production and supply of steam, water, electric, or other motive power.

CITY NOTES, &c.

AMERICAN BELL TELEPHONE COMPANY.—A quarterly dividend has been declared of 3 per cent., with 6 per cent. extra.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the past week amounted to £5,798.

BRITISH INSULATED WIRE COMPANY (LIMITED).—A private meeting of shareholders of this Company was held at the Cannon-street Hotel on Wednesday.

CITY AND SOUTH LONDON RAILWAY COMPANY.—The traffic receipts of this Company for the past week amounted to £776. The aggregate receipts for the half-year to date are £16,919.

COMMERCIAL CABLE COMPANY.—This Company announces a quarterly dividend of 1¾ per cent. upon the outstanding stock, payable July 1st. The transfer books will be closed from June 20th to July 2nd.

NATIONAL TELEPHONE COMPANY (LIMITED).—Application has been made to allow the further issue of 8,250 shares and £70,000 Four and a-Half per Cent. Debenture Stock, to be quoted in the Official List.

NOTTING HILL ELECTRIC LIGHTING COMPANY (LIMITED).—The Stock Exchange Committee have ordered shares Nos. 142 to 6,459 to be quoted in the Official List.

TRUSTEES, EXECUTORS, AND SECURITIES INSURANCE CORPORATION (LIMITED).—Sir John Pender and Mr. J. Denison Pender have ceased to be members of the Board of this Corporation.

THE ELECTRIC CONSTRUCTION CORPORATION (LIMITED).—A circular has been issued by this Company inviting the shareholders to take up the balance of the issue of Debentures recently made.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended June 5, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,546.

CRICKET.—A cricket club has been formed by the *employés* of Messrs. Laing, Wharton, and Down, 82A, New Bond-street, W., and challenges are invited from any clubs in the electrical trades. Mr. J. H. Mackail is hon. sec. and treasurer.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, June 3.		Price Wednesday, June 10		Rate per Cent. Yielded.	Dividend Due.	Business done during week ending June 10.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS.								
£1,381,380	Stock	12/0	Anglo-American	46½	47½	46½	47½	6 0 0	Jan., Apr., July, Oct.	..	..
£2,809,310	Stock	21/0	Do. Preferred	84	85	84	85	6 15 4	,, ,,	85½	85⅛
£2,809,310	Stock	..	Do. Deferred	11½	11⅝	11	11½	..	.. ..	11⅛	..
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99	102	99	102	3 18 5	January and July	..	..
130,000	£10	3/0	Brazilian Submarine	11⅜	12¼	11⅜	12¼	6 2 5	Mar., June, Oct., Dec.	12⅛	11⅞
£84,500	£100	5%	Do. 5 per Cent. Bonds	101	104	101	104	4 16 2	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	104	108	104	108	4 12 7	June and December	..	..
$7,216,000	$100	7%	Commercial Cable Capital Stock	106	108	106	108	6 0 4	April and October	..	..
16,000	10	8/0	Cuba Submarine	10½	11⅛	10½	11⅛	6 12 2	February and August	..	..
6,000	10	10%	Do. Preference 10%	16⅜	17⅜	16⅜	17⅜	5 14 3	,, ,,	..	..
12 931	5	3/32	Direct Spanish (£4 paid)	3⅞	4¼	3⅞	4¼	6 11 9	April and October	..	..
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	,, ,,	..	..
60,710	20	3/6	Direct United States	10½	10⅝	10½	10⅝	6 13 4	Jan., Apr., July, Oct	10⅝	10⅜
400,000	10	2/6	Eastern	14⅜	14⅝	14½	14⅝	4 8 2	,, ,,	14⅝	14⅜
70,000	10	6%	Do. 6 per Cent. Preference	15	15½	15	15½	3 17 5	,, ,,	15⅜	15
£1,200,000	Stock	6%	Do. 4 per Cent. Mort. Debenture Stock	106	109	106	109	3 13 5	May and November	107½	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 10 11	February & August	..	..
250,000	10	6/6	Eastern Extension	14⅜	15	14⅜	15½	4 11 10	Jan., Apr., July, Oct.	15½	14⅜
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock	105	108	105	108	3 14 1	.. ..	..	..
£91,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103	106	103	106	4 14 4	January and July	103½	..
£145,300	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	103	106	103	106	4 14 4	,, ,,	103	..
180,227	10	2 6	Globe Telegraph and Trust	9⅜	9⅝	9⅜	9⅝	5 6 6	Jan., Apr., July, Oct.	9⅝	9 7/16
180,042	10	6%	Do. 6 per Cent. Preference	15	15½	15	15½	3 18 8	,, ,,	15 5/16	15⅜
150,000	10	8⅓% fr 90	Great Northern	18½	18⅝	18½	19	4 9 6	Jan., April, and July	18⅝	18⅜
£15,000	100	5%	Do. 5 per Cent. Debentures, 1881	..	..	..	..	..	January and July	..	..
£230,000	100	5%	Do. 5 per Cent. Debentures, 1883	105	108	105	108	4 12 7	March & September	107	..
17,000	25	37/6	Indo-European	39	41	39	41	4 11 6	May and November	..	..
38,348	10	5,0	London Platino-Brazilian	6½	7⅛	6½	7⅛	6 0 0	,, ,,	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106	109	106	109	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's	8	8⅛	8	8⅛	4 14 1	April and October	8	..
3,381	£100 Cert.	6%	Submarine Cables Trust 6%	114	118	114	118	5 1 8	,, ,,	116½	116½
15,609	10	4/0	West African Telegraph	8	9	8	9	5 11 1	January and July	..	..
£290,900	100	5%	Do. 5 per Cent. Debentures	96	99	95	98	5 2 0	March & September	..	..
30,000	10	2/0	West Coast of America	3½	4⅛	3½	4⅛	..	January and July	..	..
£150,000	100	8%	Do. Debentures 8% 1902	100	105	100	105	7 12 5	June and December	..	..
88,321	10	9d.	West India and Panama	3	3¼	3	3¼	..	.. ..	3 1/16	3 1/16
34,563	10	6/0	Do. 1st Preference 6%	11½	12	11½	12	5 0 0	May and November	11⅝	..
4,669	10	34/6	Do. 6 p. c. 2nd Pref.	9½	10⅛	9½	10⅛	5 14 3	,, ,,	..	..
64,174	15	9/0	Western and Brazilian	11	11⅛	11	11⅛	6 10 7	,, ,,	11 1/16	11⅛
27,873	7½	1/6	Do. 5 per Cent. Cumulative Preferred	6½	7	6½	7	5 7 3	..	6⅝	..
27,873	7½	7/6	Do. 5 per Cent. Deferred	4½	5	4½	5	..	.. ..	4⅝	..
£200,000	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	104	107	104	107	5 12 2	February & August	..	..
£250,000	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103	106	103	106	5 13 2	,, ,,	105½	104½
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117	122	117	122	5 14 9	May and November	..	..
£175,100	£100	6%	Do, 6 per Cent. Sterling Bond	100	104	100	104	5 15 5	March & September	..	..
			TELEPHONES.								
224,850	14/0	0/4½	Consolidated Telephone Const. & Maintenance	⅛	⅜	⅛	⅜	6 14 5	May and November	⅛	..
220,000	£1	4 76	Oriental (11s. paid)	⅛	⅜	¼	⅜	5 2 11	Yearly	..	..
438,984	5	2/6	National	4⅜	4⅝	4⅜	4⅝	5 12 10	June and December	4 1/16	4⅜
15,000	10	6/0	Do. 6 per Cent. Cumulative 1st Pref.	12½	12⅝	12½	12⅝	4 14 1	,, ,,	..	..
15,000	10	4/9⅜	Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd)	11⅜	12¼	11⅜	12¼	3 18 5	,, ,,	12 1/16	..
..	£100	4½%	Do. Debenture Stk. 4½% Prov. Cert. (fully pd)	104	106	104	106	4 4 11	..	105½	104½
209,750	1	..	South of England, Ordinary	..	..	..	..	..	..	..	..
20,000	5	..	Do. 6 per Cent. Cumulative Pf. (£3 10s. pd)	..	..	..	..	..	..	..	..
58,000	5	1/0	United River Plate	2½	3½	2½	3½	..	January and July	..	..
£146,128	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 3	..	..	..
£3,200	100	..	Do. 7 per Cent. Debentures	..	..	..	..	..	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
1,000	£50	..	City of London Electric Lighting Shares (£25 pd)	30	34	30	34	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	4½	5	4½	5	..	..	..	..
5,322	£5	..	House to House Electric	4⅜	5⅛	4⅜	5⅛	..	..	..	..
30,000	£5	..	Liverpool Electric Supply (£3 paid)	2⅝	2⅞	2⅝	2⅞	3 13 1	..	..	..
111,000	5	..	London Electric Supply	1⅞	2⅛	2	2⅛	..	..	..	..
43,900	10/0	2/0	Metropolitan Electric Supply (£9 paid)	8¾	9¼	8⅞	9¼	4 7 7	..	9⅛	8⅞
7,730	£5	..	St. James' and Pall Mall	..	¼	5⅛	6⅜	..	..	..	..
..	..	7%	Do. 7% Preference	⅜	⅝ prem	⅜	⅝	..	..	4 1/16	..
42,853	5	..	Westminster Electric Supply (£5 paid)	4½	5	4¾	5¼	..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
63,416	3	..	Brush Electrical Engineering	2¼	2½	2⅜	2⅝	..	..	2 7/16	2⅜
63,416	2	1/1	Do. 6 per Cent. Preference	1⅝	1⅞	1⅝	1⅞	6 8 0	June and December	1⅝	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	4	5	4	5	7 0 0	January and July	..	..
17,130	5	..	Edison and Swan United	..	..	..	..	..	..	..	..
45,000	10	6%	Electric Construction	5	6	4⅝	5⅛	..	..	..	..
70,000	2	10/0	Elmore's Patent Copper Depositing	2⅛	3	2¼	2⅜	..	..	3⅜	3 1/16
20,000	5	..	Fowler-Waring Cables (£4 paid)	2⅜	3⅛	2	3	..	..	2⅜	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	18½	19½	18½	19½	5 2 7	February & August	19¼	18 1/16
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	104	103	105	4 5 9	March & September	..	..
11,334	£10	6/1	International Okonite Limited Ordinary	7⅛	8⅛	7⅛	8⅛	11 15 3	..	..	..
11,334	£10	5/0	Do. Preference	9¼	9⅝	9¼	9⅝	8 4 1	..	..	..
78,949	5	2/1⅛	Swan United (£3. 10s. paid)	4½	5	4½	5	9 19 10	May and November	4 1/16	..
37,350	12	36/0	Telegraph Construction and Maintenance	46	48	46	48	5 0 0	March and July	47	46
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	102	105	102	105	4 15 3	January and July	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£3 paid)	2 1/16	2 3/16	2 1/16	2 3/16	..	..	..	..
..	£5	..	Do. Preference (fully paid)	3 1/16	4 1/16	3 1/16	4 1/16	..	..	..	..
			RAILWAYS.								
50,000	£10	..	City and South London Railway	4	5	4	5	..	..	4	..

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THE ELECTRICIAN:

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NOTES.

The *conversazioni* of the Society of Arts at South Kensington and of the Royal Society at Burlington House being both held on Wednesday evening last, the overcrowding, which is the one drawback to such gatherings, was considerably reduced. The exhibits at Burlington House were of a very interesting and varied character. The electrical novelty of the evening, Prof. Perry's meter, is fully described in another column, but Prof. J. J. Thomson's induced discharges in vacua were carried out with such complete success, compared to the efforts which were made at a recent meeting at Cambridge, that they, perhaps, constituted the chief feature of interest to students of physical science. The residual glow in a bulb containing rarefied oxygen, persisting for more than half a second, appeared to be a thick yellow fog, and seemed to have an actual opacity. We understand that the spectrum is continuous, while with air the usual bright lines are seen. In hydrogen, no residual glow is found, nor has it been observed with CO_2. In some of the experiments, primary coils of glass tube filled with mercury were used, and in others gutta-percha covered wires were employed. Mr. Wimshurst showed an influence machine working as a motor, and developing a good deal more power than might have been expected.

The beautiful and suggestive experiments on "electrical evaporation," exhibited by Prof. Crookes, have one great advantage over the electro-magnetic theory: they do not require a peculiarly receptive spirit to bring home conviction. On first reading Prof. Crookes' recent Paper, describing these experiments, we thought that he had preferred an apt title to an accurate one; but careful perusal showed us that if the phenomenon described is not of the nature of evaporation, it is difficult to see what it can be. One of the most interesting results of these investigations was the extraordinary power of occlusion exhibited by the freshly-evaporated platinum. Although the tubes were exhausted until very high vacua were reached, the deposited platinum was nevertheless able to occlude the residual gas to an extent sufficient to necessitate the introduction of air every half-hour to reduce the vacuum.

A simple device for extinguishing the spark at a switch on a breaking circuit was shown by Prof. Perry. It is well known that sparking may be stopped by shunting with a condenser, but to absorb the spark which would be produced by a ten-unit dynamo, about sixteen hundred million microfarad condensers would be required. Varley has long ago pointed out that a voltameter acts as a condenser, and Prof. Perry, accordingly, provides a few simple cells, and arranges the switch so that just before contact is broken the cells are put in shunt with the switch. When the handle is moved on, the circuit is broken and discharges into these cells, and on pushing the handle right back the shunt circuit is opened. An industrious historian informed Prof. Perry, on Wednesday last, that the idea was very old, but such inevitable discoveries frequently show that the prior inventor either omitted some practical detail, or, at all events, failed to properly bring his invention before the public.

We are glad to see that the Electrical Trades Section of the London Chamber of Commerce are not allowing the proposals to hold electrical exhibitions at the Crystal Palace and at Taunton to pass unnoticed; but will consider, on Monday next, their attitude in the matter. The fact that such exhibitions, concerning, as they do, practically, one trade alone, are organised without any consultation of a well-established representative body of that trade, goes to prove that they are almost invariably promoted either for the mere profits of the promotion, or as a side-show at a place of amusement. The first electrical exhibition at the Crystal Palace was of great value to trade and to science. The arrangements were well carried out, no charge being made for space. It was thoroughly representative, and formed a valuable supplement to the Paris Electrical Exhibition of 1881, which will for ever remain as the landmark, if not the very starting point, in the history of practical electrical engineering. The exhibition at the Aquarium in 1883 was the occasion of the first display of alternate-current transformers. Nor was the electrical section of the Inventions Exhibition devoid of advantage to the exhibitors and of interest to the intelligent public. The electric lighting department at the Manchester Exhibition of 1887 was remarkable only for one exhibit of an important local firm, and the same may be said for that of Glasgow and other provincial exhibitions. It is one thing to invite contractors to light an exhibition—and very badly they sometimes do it—and another thing to attempt to make a show which shall be representative of the present state of the industry. There was not the smallest desire for the Edinburgh Exhibition. The Chamber of Commerce exacted the condition that the rental for space should be refunded from the profits, and fortunately for the exhibitors this arrangement did not constitute a partnership, and they were not called upon to alleviate the lamentable failure which ensued.

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YOUNG firms, of course, need but little inducement to make a show, and they are quite right in doing so. Their principals can afford to attend nearly every day, and they generally have, or ought to have, some novelty or speciality to introduce. But we have heard of one solitary advantage which may possibly make it worth while for well-established contractors to put in appearance at electrical exhibitions, and it is this. Numerous local authorities have obtained provisional orders, and do not know what to do with them. They are afraid to carry out the work themselves for they are aware that they know nothing about electrical engineering; and they are afraid to take advice, for they are aware that they know nothing about electrical engineers. With praiseworthy zeal they make excursions to visit various central stations, to interview their managers, and to try to understand the general principles of generation and distribution of electrical energy. Of course, the general principles are the very last matters that they are likely to learn. What they do is to bewilder themselves with a mass of facts unrelated and undigested. In the course of their journeyings they are very likely to go to the Crystal Palace, and it is quite worth the while of a contractor to put himself in the way of such a party But if the presence of the leading firms will make the exhibition a success, they should certainly have a voice in the management.

THE exhibition at Taunton is on another footing, and is chiefly of local interest. Like the exhibition at St. Pancras, it may be of service in showing the residents in the neighbourhood what can be done with electric light and power, and how to do it. There is no need for the extensive display of the wares of important firms. Such a show should stimulate demand for electric supply, and there may be some profits for the promoters, who, in this case, occupy a very legitimate position.

IN our Notes Column will be found a very interesting account of the electric disturbances which have been detected at Greenwich Observatory, caused by the earth currents arising from the operation of the City and South London Railway. The facts that the nearest earth-plate connected with the Observatory was nearly three miles in a direct line from the railway, and that the plates were often found to differ in potential by more than one-third of a volt, show that electric leakage takes place to a very considerable extent. This is due to the fact that the iron tube is connected throughout its length both with the return rails and with the earth. Each section of the tube thus acts as a large earth-plate discharging current into the soil. The proportion of the current which returns to Stockwell in this way may be unexpectedly large, owing to the amount of surface exposed. This distribution of current, too, is favourable to the production of magnetic disturbances, because the return current does not, as in the Deptford cable, completely enclose the outgoing current, as is proved by the existence of these earth currents. Even if the iron tube acts perfectly as a magnetic screen, it becomes circularly magnetised, owing to the unsymmetrical distribution of the current, and may thus cause variations in the intensity of the vertical component of the earth's magnetic force.

THE two Papers dealing with the chemistry of the secondary cell recently read before the Royal Society, abstracts of which will be found in another column, while not bringing us appreciably nearer that bourne of the practical electrical engineer, a really satisfactory storage cell for lighting and traction purposes, elucidate several hitherto obscure points. Having ascertained beyond doubt the presence in the electrolyte of large quantities of persulphuric acid and hydrogen dioxide, Mr. ROBERTSON and Prof. ARMSTRONG are able to explain the efficacy of Mr. BARBER STARKEY'S sodium sulphate treatment, the occasional reversals, the recovery of a rapidly discharged cell after rest, the abnormally high volts after charging, &c. Prof. FRANKLAND'S argument that the sulphate formed during normal charge and discharge *must* be different to the ordinary irreducible white sulphate, since it was not white and was easily reducible, already controverted last summer by Messrs. GLADSTONE and HIBBERT, is also further demolished in the present contribution.

THE claim made by the manufacturers of the substantial switch which is illustrated in our Trade Notes, viz., "a 'large margin of safety' two and a-half times amount of theoretical contact surface," reminds us of the curious anomaly existing in the present custom of denoting the size of a switch by its carrying power in amperes. The three points about a switch are—its general design, its "carrying power," and its price Disregarding for the present such special switches as the two-way and double-pole, in some cases we must have sudden break, in others we need a long break. On many occasions an independent sparking piece is necessary, and a proper design should be chosen for each case. But if we order a 60-ampere switch from one maker he will send us an elaborate piece of mechanism, for which he is justified in charging £2. 10s., while another will send a production which he honestly believes will carry the required current without heating, and asks half-a-sovereign for the modest contrivance. Carrying power depends on the surface in actual contact, and on sectional area of the bridge. The latter should never give trouble. Engineers are familiar with the surfaced joints which WHITWORTH taught them to make. But everyone who has made a surface block for himself, or has even scraped a valve face, knows that as the work progresses the points of contact become more numerous, and, in the best work, lie evenly distributed and close together. But for all that they are points, and there are only a limited number to the square inch, and a very small amount of grinding together will destroy the truth of the plane if only on account of irregularities in the hardness of the metal.

IT is cheaper to put plenty of bearing surface in a switch than to spend work in the accurate surfacing of a small area. If a steam valve has a "full-way" and a sufficient area, we know what it will carry, but if we want a switch to carry 400 amperes it is better for a purchaser to trust to some maker who, having gained practical experience, has a reputation to lose, than to attempt to specify the square inches of bedded contact surface. We were so interested in hearing for the first time of "a theoretical contact surface" that we made inquiries

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about it from the makers. The result is a little disappointing; we learn that "supposing the current to be carried to be 100 amperes, the section of the switch arm immediately behind the interlocking jaws would be at one square mm. per ampere, say 15mm. broad by 7mm. deep, and the jaws should, of course, have, theoretically, a bearing surface equal to the area of this section. In the switch illustrated, however, this area is multiplied by 2½, or, say, 270 square mm., and when it is considered that each tongue in the switch has at least four bearing points, the margin of safety should be ample." So we learn nothing, after all, about the "theoretical bearing surface" other than that it should be equal to the area of the section. If the sectional area of the arm is satisfactory, but not lavishly designed to carry the current without heating, we should say that the working surface should be, at least, ten times this area; but it is obvious that the switch under consideration has a much better contact surface than the information which we have quoted would lead us to imagine.

"THE ELECTRICIAN" Primers (2 vols.) are now ready. They are intended for elementary readers, and, as considerable care has been devoted in their compilation to precision and clearness, we venture to think that they will prove of considerable assistance to students in grasping the fundamental principles of theoretical and applied electricity.

Cable Extensions.—The duplicate cable connecting Calais with Fano (Denmark), will be laid at the end of July.

Telephone Trunk Wire Extensions.—The Paris-Amiens telephone line, 81 miles in length, was opened to the public on Monday last.

Barnet.—The Local Board have finally determined to discontinue the public lighting of their district by electricity, and to revert to gas, on and after September 1st.

Appointment Vacant.—Applications are invited for the appointment of demonstrator in the department of mechanism and applied mechanics at the University of Cambridge. Further particulars will be found in our advertisement columns.

Society of Arts.—The Council of the Society of Arts, on Wednesday night, gave a *conversazione* at South Kensington Museum. Sir Richard Webster, the Attorney-General, attended by Sir Henry Wood (the secretary), received the visitors, who numbered about 2,000.

Junior Engineering Society. — On the 30th ult., a large party of members of this Society visited the locomotive, carriage, and wagon works of the London, Chatham, and Dover Railway, Wandsworth-road.—The address of the Society's office is now 29, Fentiman-road, Clapham-road, S.W.

Portrait of Major Flood Page.—We have received from Mr. G. B. Black, of 21, Baker-street, W., an excellent lithographic portrait of Major S. Flood Page. Not only is the likeness extremely good, but the artist has caught and has very faithfully rendered a very genial and natural expression.

The Telephone in Berlin.—The subscribers to the Berlin telephone exchange now numbers about 16,000. During the past year nine new lines have come into operation, viz., those to Bankenburg, Gröningen, Lauban, Oschersleben, Osterwiek, Penzig, Quenlinburg, Shale, and Wernigerode.

Electric Mining Machinery.—According to American consular reports from Singapore, gold mining is rapidly developing at Raub, in the Province of Pahang, Malay Peninsula, and the operators are negotiating with American firms for stamp mills, water-wheels and electrical machinery.

The Brillie Meter.—The fact that the Brillié meter, which was awarded a prize in the first competition initiated by the Paris Municipality, should not have even been mentioned in the second has caused some comment, especially as the inventor claims to have considerably improved the meter between times. However, if it be true that the only specimen sent in refused to work, the less said the better.

Royal Society.—The following Papers were down for reading before the Royal Society yesterday:—Dr. J. Hopkinson, "Note on the Density of Alloys of Nickel and Iron;" Oliver Heaviside, "On the Forces, Stresses, and Fluxes of Energy in the Electro-magnetic Field;" Prof. W. G. Adams, "Comparison of Simultaneous Magnetic Disturbances at several Observatories, and Determination of the Values of the Gaussian Functions for those Observatories."

University and King's Colleges.—The hearing by the Privy Council of the petition of University College and King's College for the establishment of a Teaching University in and for London has been fixed for Monday, the 29th inst., at 11 o'clock. Mr. Rigby, Q.C., and Mr. H. Cunynghame have been retained by the petitioners. It is understood that the University of London will limit itself to a watching of the proceedings for the protection of any interests of its own that may appear to be affected.

Dublin.—Work has commenced in connection with the Municipal Central Station. The site is about one-quarter of an acre in extent. The private lighting plant will comprise three 300 H.P. engines, by Coates and Co., of Belfast, each of which will drive a 2,000-volt Lowrie-Hall alternator through rope gearing. The public lighting plant will comprise three 60 H.P. Brush engines and three 55-light Brush dynamos. The cables will be laid in iron piping. The public lights will probably be started in November.

Owens College.—An essay prize of £10 on "The Technical Applications of Electricity" was offered for award in the session 1890-1 by Mr. W. Mather, M.P., and a prize of a similar sum is offered for award by Dr. Edward Hopkinson in the session 1891-2. The subject for the essay in the current session was "Recent Progress in Magnetism," and Mr. Mather's prize has been awarded to Bertram S. Giles, a student in the evening classes of the college. The competition is open to both day and evening students in the Physics Laboratories.

Societe Francaise des Telegraphes sous Marins. — The opening is announced to the telegraphic services of the new cable belonging to the Société Française des Télégraphes sous Marins, between Puerto Plata and Martinique. A new cable (the Haïti line) has also been opened in connection with Martinique, Guadeloupe, and Dutch Guiana, with a reduction of 2s. 6d. on the present tariff. The Société des Télégraphes sous Marins has just opened a new station at Cape Haïtien (Haïti). The head office of the Society is at 32, Rue Caumartin, Paris.

Sir Frederick Abel.—The Albert Medal of the Society of Arts for the present year has been awarded by the Council to Sir Frederick Abel, in recognition of the manner in which he has promoted several important classes of the arts and manufactures by the application of chemical sciences, and especially by his researches in the manufacture of iron and of steel; and also in acknowledgment of the great services he has rendered to the State in the provision of improved war material, and as chemist to the War Department.

Electrolytic Galvanising.—According to a patent just taken out in Germany, by Schaag, of Berlin, and a Baden firm, the following is a method of obtaining, by way of electrolysis, an adherent deposit of zinc:—Salts of magnesium and mercury are added to the ordinary bath. The addition of magnesium increases the conductivity without increasing the acidity of the solution. The deposited zinc contains a minute trace of magnesium, which renders it hard and adherent. The mercury is said to ensure a regular white deposit.

The Electric Light at the British Museum.—Alterations and additions are being made to the electric lighting apparatus at the British Museum. After July 4th next it is proposed to throw the whole of the Museum open to the public in the evenings, instead of, as has hitherto been the practice, admitting visitors to the eastern and western galleries on alternate nights.

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This is a step in the right direction, but a still greater convenience to the public would be, as we have already pointed out, the throwing open of the Museum during the entire day from 10 a.m. till 10 p.m. The closing for a few hours until the reopening at 8 is probably one reason for the comparatively scanty attendance in the evenings.

The Chelsea Electric Lighting Provisional Order.—The Bill embodying this order came before a Select Committee of the House of Commons on Monday. Sir S. Northcote presided, and the other members of the Committee were Mr. F. T. Barry, Mr. J. Wilson, and Mr. E. Kuatchbull-Hugessen. Mr. Pember, Q.C., who appeared for the promoters (the New Cadogan Company), said it had been arranged with the opponents (the London and Chelsea Companies) that the order should go unopposed on the understanding that the opponents were not to be prejudiced by what had occurred in that House. If a settlement was not arrived at, the opponents would be perfectly free to oppose the order in the other House, and he undertook to make no reference whatever to the present proceedings. The order, therefore, passed unopposed.

London Chamber of Commerce.—A meeting of the committee of the Electrical Trade Section will be held on Monday, the 22nd inst., at 3 p.m., to consider the following agenda:—(1) Correspondence: letter from one of the witnesses who attended at the Board of Trade in the matter of the inquiry into electrical standards; overhead wires; letter as to Prof. Mengarini, of Rome, being about to transmit 2,000 H.P. from Tivoli to Rome at a pressure of 5,000 volts along bare wire. (2) To consider the desirability of placing wires underground in future. (3) To consider the attitude of the Electrical Section towards the proposed Crystal Palace Electrical Exhibition and also the Taunton and South-West of England Electrical Exhibition. (4) Frankfort Exhibition: to consider whether a party from the Section should visit the Exhibition from, say, August 5th to the 15th.

The Proposed Pacific Cable.—The following extract is from the *Shanghai Mercury* of May 1, 1891. Up to the present time the greatest depth from which a submarine cable has been recovered is 2,720 fathoms:—"The survey made by Rear-Admiral Belknap, U.S.N., of the North Pacific, demonstrates that the proposed great circle for a submarine cable is not feasible. His soundings indicate the existence of a trough or basin or of extraordinary depth and extent, along the east coast of Japan and the Kurile Islands, and under the Kuro Siwo, or Japan or Black Stream. The basin exceeds any similar depression yet found in any other regions of the great oceans. In a run of 30 miles, after leaving the coast of Japan, the waters deepened more than 1,800 fathoms, and upon the next cast of the lead the wire broke, after 4,643 fathoms had been run out without bottom having been reached. Thermometers, specially constructed for deep sea sounding, were wrecked by the unprecedented pressures. The depth of the deepest cast—five miles and a quarter, the deepest water yet found—is sufficient to hold two mountains as high as Japan's great Fusiyama, one on the top of the other, and then the summit of the highest would be nearly two-thirds of a mile under water. This region of the Pacific has been named the 'Tuscarora Deep,' after the vessel that made the survey."

The Electric Transmission of Power from Tivoli to Rome.—The first idea of transmitting power by means of electricity from Tivoli to Rome was due, says M. F. Cardarelli in the *Giornale delle Communicazioni*, to the Società per le Industrie Idrauliche, and the large hydraulic works carried out with a view to the execution of the original plans are now being made use of in connection with the scheme of the Società Anglo-Romano per la Illumazione di Roma. This scheme involves the transmission to a distance of 18½ miles, and at an electrical pressure of 5,000 volts, of some 2,000 H.P. The motive power is obtained from the Anio, whose waters, after having been utilised by various industrial establishments, will be collected in an aqueduct, 1¼ miles long, and conducted to the turbines, where a head of 165ft. and a flow of 770 gallons per second are available. The generating plant is to consist of six horizontal 360 H.P. Girard turbines, each coupled direct to a 300 kilowatt (6,000 volts × 50 amperes) Ganz alternator, and three 50 H.P. turbines coupled to exciters. The line is to be run overhead, extreme care being taken to make the supports strong and to insulate them from the soil. The poles are of iron, and are some 100ft. apart, the four bare copper conductors, made by the Società Metallurgica of Leghorn, being ranged one underneath the other, at an average height of 28ft. from the ground. Two circuits, composed of 19/12 stranded cable, will be run, the total resistance of each circuit being 10 ohms. The insulators, made by the firm of Giorni, are of the Johnson and Phillips oil pattern, modified so as to permit of rapid cleaning of the oil cup; an essential feature on this line, which is infested with insects. At Rome, a transformer sub-station is being erected near the Porta Pia, where the pressure will be reduced from 4,000 to 2,000 volts, and the current distributed at that pressure to transformers in consumers' houses by means of Siemens concentric cables. The initial pressure of the alternators is 6,000 volts, and, at full load, 1,000 volts will be lost in the armature, and 1,000 volts in the line, the pressure at the Rome transformer sub-station being kept constant by automatically varying the pressure at the dynamo terminals. It is proposed to run the dynamos in parallel. At Tivoli there will, therefore, be a variable current and a variable potential, while at Rome there will be constant potential and variable current for the private lighting network, and constant current and variable potential for the street lamps.

Earth-Currents and the City and South London Railway.—A well-marked case of interference with the earth-currents recorded at the Royal Observatory, Greenwich, due apparently to the working of the City and South London Railway, has been communicated to *Nature* by Mr. William Ellis. For years past a continuous photographic register of earth-currents has been maintained at the Observatory. There are two circuits. For one circuit the earth-plates are at Angerstein Wharf (A.W.), on the Thames, near Charlton, and at Lady Well, Lewisham (L.W.), three miles distant; for the other circuit the earth-plates are on Blackheath (B.), and at the North Kent East Junction (N.K.E.J.) of the South-Eastern Railway, two and a-half miles distant. The earth connection is in each case made by an independent copper plate. The azimuth of the A.W.-L.W. line, reckoning from magnetic north towards east, is 50°. Towards the end of last year anomalous appearances began to be observed in both of the earth-current registers, and for some months past these interruptions have settled down into a regular order. A continuous vibration of the registering needles commences shortly before 7h. in the morning, and goes on all through the day, terminating shortly after 11h. in the evening. This went on for several months on week-days only, ceasing on Sundays. But on Sunday, April 5, and on every succeeding Sunday to the present time, the interference has been experienced also on a portion of the Sunday, commencing at about 1h. p.m., and terminating usually at 10h. p.m., or shortly afterwards. Various experiments were made with the view of discovering the cause of these anomalous appearances, but without definite result. Quite recently, Mr. Leonard, the telegraphic superintendent of the South Eastern Railway, suggested that the exceptional appearances were most probably due to the influence of the Electric Railway. A comparison being made between the observed times of interference with the earth-current registers, and the published times of running of the trains, it was found that these were simultaneous. The line of the Electric Railway runs from about north-east to south-west magnetic, or, more accurately, the azimuth of the line, reckoning from magnetic north towards east, is about 50°. The nearest earth-plate to the railway is the N.K.E.J. plate, which is distant from the railway, in a perpendicular direction from it, about two and a-half miles. The correspondence so far as the comparison goes is complete. During the periods of interference the registering needles at the Observatory are in continual vibration. Whether the impulses are in one direction only or in both directions, and what is their frequency, cannot be readily determined from the registers. Eye observation of the needles may, perhaps, reveal something to us on these points. The abnormal excursions of the needles indicate a change of potential varying from a small fraction of a volt to perhaps the one-third of a volt or more.

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MAGNETISM IN IRON AND OTHER METALS.*—XLIII.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 154.*)

§ 149. **The Magnetic Circuit.**—For many purposes, the most convenient way of treating the magnetisation of iron is to consider what is happening at a point within the metal. This is, in fact, the basis on which our exposition of the subject in earlier chapters has been developed. We have learnt to conceive of a magnetic force H acting in a definite direction at the point considered, and also of a magnetic induction B at the point. If the material is isotropic, and has no residual magnetism superposed upon the magnetism which H induces, the direction of B is the same as that of H. The ratio of B to H is the permeability μ. Passing from point to point of the metal, we may in certain cases find that H and B do not change; more generally they do change. Thus, in a uniformly wound circular ring magnet, of uniform section and material, H has the same value at all points on any circle co-axial with the ring. In a long straight bar magnet the value of H is nearly uniform, except in the neighbourhood of the ends. Whether H be uniform or not, it has a single definite value and definite direction at each point, and the same thing is true of B. At points where there is no magnetisable substance, the value and direction of B are the same as the value and direction of H; this applies, for instance, to all points in air. The value of H at any point is determined by finding the resultant of the force produced at that point by (1) all the conducting circuits, and (2) all the free magnetism in the neighbourhood; that is, by finding the resultant mechanical force which would be felt by a unit pole of free magnetism if placed at the point in question.

From this point of view, when our object is to discuss the magnetisation of a piece of metal, we have first to consider what is the value of H at each point within the piece. Thus, in dealing with a uniformly-wound ring, we treat the case by finding that the magnetic force H is $4\pi C n$, when C is the current and n is the number of turns in the magnetising coil per centimetre of the ring's length. And in dealing with a uniformly-wound rod, we find H to be $4\pi C n$ *minus* a certain quantity which is due to the free magnetism at and about the ends, and which becomes unimportant when the rod is exceedingly long. Many problems in magnetism are best treated in this way, namely, by considering the condition of things at individual points in the magnetised piece.

But there is another way of regarding the matter, not in the least antagonistic to this, but sometimes more convenient. Instead of thinking about what happens at individual points, we may view the the magnetism of the piece as a whole, by considering what is called the *magnetic circuit*. This is the method which has been applied by J. and E. Hopkinson† and by Kapp,‡ to pre-determine the magnetism of dynamos. Its applicability to dynamos and transformers give it peculiar importance on the practical side; moreover, apart from that, the conception of the magnetic circuit has much interest as an alternative standpoint from which the facts of electro-magnetism may be viewed, and as suggesting methods of experimental enquiry.

§ 150. **Tubes of Magnetic Induction. Definition of Magnetic Flux and of a Perfect Magnetic Circuit.**—The lines of magnetic induction, as has been already pointed out (§ 14) are continuous through space, whether the space is filled with magnetisable or non-magnetisable substance, or partly with one and partly with the other. There is no discontinuity of B—no sudden change in its value or direction—when the lines pass from metal to air or from air to metal. Each line of induction is a continuous curve; moreover, it is a *closed* curve—that is to say, if traced along its whole course it returns to the point at which the tracing began. We may conceive of all space as filled with sheafs of lines of induction, or (which is the same thing in other words) as partitioned into tubes, the boundaries of which are formed by lines of induction. Every such tube contains a number of lines of induction, and if we follow the tube along its whole length until it returns into itself we find everywhere the same number of lines of induction in it. We may take a large sheaf or a small one to constitute the tube, but, whatever be the number of lines in it to start with, the same number is present at every part of its length. Its cross section may vary; the tube may widen or contract from place to place along its length, but if this happens it is by the lines spreading out or coming closer; the number of the lines does not change. At places where the induction B is strong, the tube is contracted; at places where the induction is weak, the tube is expanded. But if we take any cross sections (s) of the tube perpendicular to the direction of B, the product $B s$ (or to be more exact, the surface integral $\int B\,ds$ taken over the section, since B is not necessarily the same over all parts of s*) is a constant quantity for any one tube. At any sections s and s', the values of the induction B and B′, are such that $\int B\,ds = \int B'\,ds'$. It is convenient to have a name for this constant quantity, which is the whole number of lines of magnetic induction in the tube. Following the usage of several recent writers we shall call it the *magnetic flux* in the tube.

Any tube of magnetic induction, considered as a whole—that is to say, considered as a circuit which returns into itself—may be called a *perfect magnetic circuit*. The perfect magnetic circuit is analogous to a perfectly insulated electric circuit conducting a current. The lines of induction correspond to lines of flow of current. The cross-section of the conductor may vary from place to place, but the current density varies in inverse proportion to the cross-section and the product of current density into area of cross-section—which is simply the whole current—is constant at all sections, just as the flux $B s$ is constant in the perfect magnetic circuit.

§ 151. **Imperfect Magnetic Circuit.**—An imperfectly insulated electric circuit allows some of the lines of flow to enter it or to leave it through the sides. We have the magnetic analogue of this when we have to deal with the magnetisation of a material ring of any form, in which the sides of the ring do not coincide with the sides of a tube of induction. This means that there are places where some of the lines of induction leak out, so to speak, from the substance of the ring through its sides into the surrounding medium. It is often convenient, especially when the greater part of the whole flux remains in the ring, still to speak of such a ring as a magnetic circuit. We shall distinguish it from a true tube of induction by calling this leaky ring an *imperfect magnetic circuit*. It is imperfect, inasmuch as it leaves out those portions of the surrounding medium through which some of the lines of induction stray, the inclusion of which would be necessary in order to make the tubes of induction complete. Examples of imperfect circuits will be given presently.

§ 152. **Line Integral of Magnetic Force, or Magneto-Motive Force.** We have now to express the relation of the magnetic flux in a perfect magnetic circuit to the whole magnetising agency acting on the circuit, just as in a perfectly insulated electric circuit we express the relation of the current to the whole electromotive force that is operative throughout the circuit.

We have in the magnetic circuit an agent to which (when we are dealing with induced magnetism) the magnetic flux is due, which corresponds to the electromotive force of the electric circuit. To this agent Bosanquet† has given the name of *magnetomotive force*.

One way of defining the electromotive force of an electric circuit is to say that the electromotive force is the amount of work which would be done in carrying unit quantity of electricity completely round the circuit.

In the same way we may define the magneto-motive force of a magnetic circuit as the amount of work which would be done in carrying a unit magnetic pole completely round the circuit. At any point of its path the unit pole is acted on by a mechanical force which is equal to and in the direction of the magnetic

* All rights are reserved. † *Phil. Trans.* ‡ *Jour.* Soc. Tel. Eng.

* The cross section, over which this integral is calculated, is taken so that every element of the surface is perpendicular to the lines of B which cut it. Thus, if the lines of B in the tube are not parallel, the surface forming the cross section will be curved.

† Bosanquet, *Phil. Mag.* 1883, Vol. XV., p. 205.

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force H, and it is against this mechanical force that the work is done.

Another name for the same quantity is the *Line Integral of Magnetic Force*, taken round the circuit.* Conceive the path along which the unit pole is moved to be made up of a great many short pieces, any one of which is so short as to be sensibly straight and to have a sensibly uniform value of H from end to end of it. Let the length of any short piece be δl, and let its inclination to the direction of H be ϵ. Then the work done in moving the unit pole along this short piece of the path is measured by the product of the length of the path (δl) into the component of the force H along the path; that is to say, it is $H \cos \epsilon \delta l$. The whole work done in moving a unit pole along the path is got by summing up the work done at each short piece; that is to say, it is $\Sigma H \cos \epsilon \delta l$, or $\int H \cos \epsilon \, dl$ when the elements into which the path is divided are indefinitely numerous and indefinitely short. The expression $\int H \cos \epsilon \, dl$ is the line integral of the magnetic force along the path.

We may integrate the magnetic force in this manner along any curve whatsoever. The term line integral of magnetic force is not in the least restricted to cases in which the integration takes place round a magnetic circuit. Let the path through which the unit pole is supposed to be carried, extend through space in any manner the line integral, namely, $\int H \cos \epsilon \, dl$, measures the work done in carrying the pole along it.

In cases where the direction of the line coincides at all points of its course with the direction of H, $\cos \epsilon$ is everywhere unity, and the expression for the line integral of the magnetic force becomes $\int H \, dl$. This is generally† the case when the line in question is a line of magnetic induction, that is to say, when the line integral of magnetic force is calculated for a perfect magnetic circuit.

§ 153. **Value of the Line Integral of Magnetic Force.**—When the integration is extended all along any closed curve, in other words, when the imaginary unit magnetic pole makes a complete journey along any path which returns into itself, it may be shown that the line integral of magnetic force admits of very easy calculation. If the curve along which it is reckoned does not thread its way through any circuit in which a current is flowing, then the value of the line integral of magnetic force along the closed curve is zero. If the curve does thread its way once through a circuit in which a current C is flowing, then the value of the line integral of magnetic force along the closed curve is $4 \pi C$; and if the curve threads its way N times through such a circuit, the value of the line integral is $4 \pi C N$. For, example, if the line along which the line integral of magnetic force is reckoned is any closed curve which is threaded through the interior of a coil of N turns, the line integral is $4 \pi C N$, for the line is interlinked with the current circuit as many times as there are turns in the coil.

The principle that the line integral of magnetic force is equal to $4 \pi C N$, when taken along any closed curve is an absolutely general one. It is true whatever be the position and direction of the curve, whether it lie along a line of force or no, and whether it lie wholly or partly in a non-magnetisable substance, such as air, or wholly or partly in a magnetisable substance such as iron. If the closed curve threads through more circuits than one, the sum of the terms $4 \pi C N$ is to be taken.

Two simple cases will serve as instances. Suppose we have a uniform solenoid of n turns per centimetre, and l centimetres long. Let the ends be bent together so that it forms a closed ring. The length of a closed curve in the centre of the solenoid is l. The magnetic force H is uniform all along that line, and is equal to $4 \pi C n$. The value of $\int H \, dl$ is, therefore, $H l$ or $4 \pi C n l$, or $4 \pi C N$, since N the whole number of turns $= n l$.

Again, consider the magnetic force around a long straight conductor (the remainder of the circuit lying so far off as to be uninfluential) and integrate $\int H \, dl$ along the circumference of a circle of which the conductor is axis. The force at any distance r from the axis of the conductor is $\frac{2C}{r}$. This is uniform throughout the circular path, and is in the direction of the path. The length of the path is $2 \pi r$. The line integral of magnetic force round the path is, therefore, $\frac{2C}{r} \times 2 \pi r$ or $4 \pi C$. In this case the path along which the line integral is taken is interlinked with the circuit only once.

The principle set forth in this paragraph may be stated thus:—The line integral of magnetic force along any closed curve is equal to 40π, or 125·66, into the number of *ampere-turns* in the coil or coils which are threaded by the curve.

(*To be continued.*)

* Maxwell, "El. and Mag.," Vol. II., § 401.

† Namely, when the medium is isotropic and has no residue of previous magnetisation in a direction inclined to the direction of H.

STANDARD CELLS.

At a recent meeting of the Franklin Institute, Mr. Carl Hering described a modified form of Daniell standard cell, devised by him with a view of having it always ready for use. It consists of two bottles containing two liquids with their respective electrodes, the bottles being connected at their bottom by a small tube with two stopcocks, the portion of the tube between the two cocks communicating directly with the air. By this means the liquids, which mix at their contact, are allowed to drain off as rapidly as they mix. To prevent too rapid a flow some filter paper, cotton, or asbestos, is packed into the tubes. The intermediate tube may be drained completely; there is always a film of liquid sufficient to answer for a contact if the cell is used on open circuit. The internal resistance of the cell is naturally high (10,000 to 20,000 ohms). The E.M.F. of a Daniell, according to Dr. Fleming, is 1·105 true volts at 16°C., when the specific gravity of the zinc solution is 1·2, and that of the copper is 1·2, when the zinc is amalgamated, and the copper is freshly electro-plated with an untarnished, salmon-coloured coating, having no brown spots. The solutions and metals must be perfectly pure, and the solutions made with distilled water and filtered, being diluted to the required amount after filtration. Such a cell may be kept standing indefinitely, and is always ready for use. The only remaining objection is that the copper electrode does not remain clean. It should be freshly electro-plated, before using, which is readily done in a test tube with a platinum anode. To overcome this, Mr. Carl Hering suggests the amalgamation of the copper, and when not in use to keep it in a tube of mercury.

In experimenting with this cell a curious phenomenon was noticed. It was found that the slight pressure produced in the bottles by inserting the corks at the top, produced decided differences in the E.M.F. of the cell; this was noticed for each of the liquids, and was different in the two cases. It was, therefore, found essential to use a cork with a hole through it, so as to prevent this pressure from being exerted.

Writing in the New York *Electrical Engineer* of June 3rd, Prof. Cahart states that the effect of pressure upon E.M.F., mentioned by Mr. Carl Hering, is not quite new, as may be ascertained by referring to Tommasi's "Pile Electrique," p. 364. The suggestion that the necessity of freshly electro-plating the copper electrode every time it is used might be avoided by amalgamating the copper, would, he says, be a very disappointing one to put into practice; for amalgamated zinc and amalgamated copper give a much smaller E.M.F. than the normal one of the Daniell cell. Moreover, it is quite as important that the zinc should be as free from oxide as the copper. Considering these facts, and the extreme difficulty of preventing admixture of the two sulphates, whoever has had the use of a good Clark cell will never, he thinks, be willing to employ the Daniell, except in case of necessity.

The high temperature coefficient of the Clark cell can hardly be urged against it now, since its value has been reduced to half its former one. As an indication of the permanence and reliability of the Clark cell, Prof. Cahart quotes some figures obtained by him relating to a Clark standard made four years ago after Lord Rayleigh's directions, to two more made two months ago, and to a Rayleigh cell, four years old, put up in a wide-mouthed bottle, which had been used promiscuously by perhaps one hundred students in the laboratory. A

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comparison of the four cells on April 1 gave the following relative value of the E.M.F., the numbers given being the ohms required to effect a balance by the Rayleigh method of comparison: old Rayleigh cell, at 20·5°C., 9,118; first new Raleigh cell, at 20·5°C., 9,118; second new Rayleigh cell, at 20·5°C., 9,116; cell in bottle, at 20·5°C., 9,117. One week later, at 12·7C., the first three gave 9,179, 9,176, 9,176 respectively. The other was not compared.

In conclusion, Professor Cahart says:—"I have 10 cells, of my own special make, in a rack by themselves, that never, I think, show an extreme difference among them of more than five parts in ten thousand. I consider Clark standard cells quite indispensable in an electrical laboratory."

MAVOR AND COULSON'S METHOD OF CONCENTRIC WIRING.

The concentric system of electric light wiring for buildings and ships is now attracting a good deal of attention. Notwithstanding several advantages which it offers over double wiring in simplicity and security, the prejudices of insurance companies have, in many cases, blocked the way to its introduction. While the advantages of concentric wiring for land work are great, they are even more conspicuous for ship work. The facility with which this system of wiring can be made thoroughly water-tight is the strongest possible argument in its favour for ship use. The British Admiralty have partially recognised this, and have adopted lead sheathed conductors for electric lighting and also for electric bell circuits, torpedo and gun-firing circuits, &c.

The concentric watertight cables used by Messrs. Mavor and Coulson, of Glasgow, for ships' work, are for the most part manufactured by the Fowler-Waring Company. They are lead

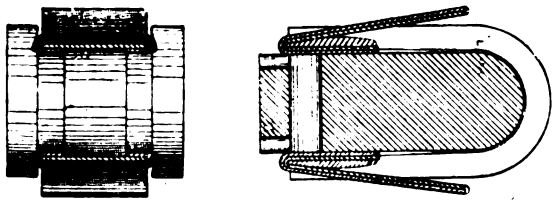

Fig. 1.—Porcelain Fuse Block with Copper Springs held in Undercut Grooves.

sheathed, and are protected by an armouring of iron wires laid over the lead on a cushion of jute. In the case of branch wires in cabins, the iron sheathing is dispensed with, and the outer conductor is formed of a copper braiding laid on under the lead tube. The principal object of this braiding is, in the case of short circuit, to carry sufficient current to burn out the fuse without fusing the lead sheathing of the conductor. The smallest size of conductor used is No. 14, S.W.G., and this carries current for eight lamps.

These branch conductors, each carrying a group of eight lamps, radiate from distributing boxes, which contain a fuse, and, if desired, a switch, for each group. The distributing boxes are of cast iron, and each contains from four to ten fuses, mounted on a slate base, and is thus the centre of distribution for from 30 to 80 lights. The main conductor from the dynamo or main switch board enters the fuse box at a tail cast in the side of the box. The core of the cable is carried into the terminal block on the distributing bar. The end of the insulation is treated with water-tight compound, and a soldered joint is made between the tail and the lead sheath of the cable, the iron armouring being also bound to the tail. Each branch wire is led through a similar tail in the top of the box, a soldered joint being made between the tail and the lead sheath of the conductor. The cover of the box is of plate glass, in a cast iron or brass frame, screwed against a rubber joint.

The fuses (Fig. 1) are tin foil strips mounted on porcelain blocks, with copper contact springs. They are all interchangeable and of uniform size.

The advantages of these distributing boxes in affording facilities for testing are obvious. All branch conductors are of the same size, viz., No. 14 S.W.G., and this size is carried into the base block of every fitting and into every switch. The base blocks to which the fittings are fixed are of cast brass. In every case the lead sheathing is soldered to the tail, and the end of the insulation of the conductor protected against moisture. The end of the central conductor is secured under a small disc, which is mounted on a slate base. Against this disc the contact terminal in the fitting is pressed by a buffer spring, when the fitting is screwed into the base.

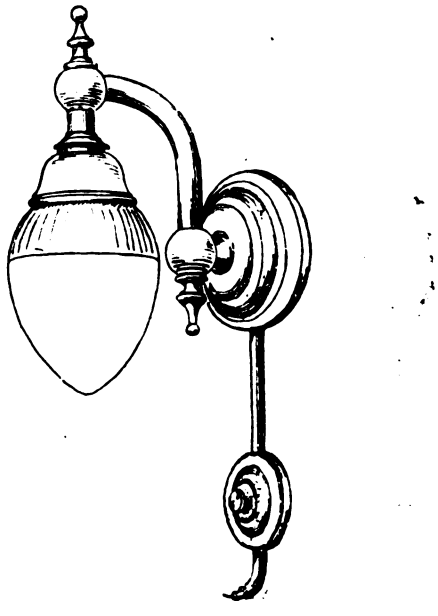

Fig. 2.—Fitting with separate Switch.

The switches, where practicable, are combined with the fittings, but when separate switches are required that shown in Fig. 2 is used. The box is of cast brass, with projecting tails, to which the lead sheathing of the conductors is soldered, the central conductor being also soldered to two terminal studs fixed in a slate base in the box. The switch shown in section in Fig. 3 is a double-threaded quick screw working in the cover, pressing a small insulated disc D on the contact studs C C. A small spiral spring S raises the disc off the contacts when the pressure of the screw is released. The fittings are wired with

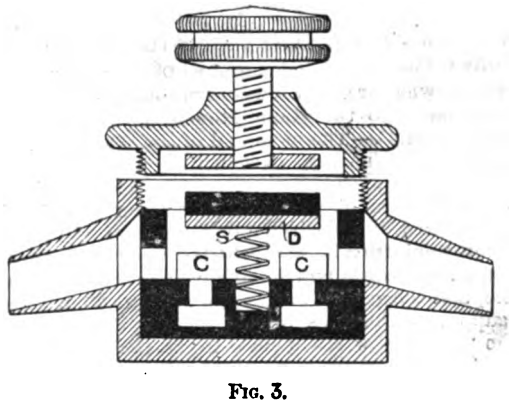

Fig. 3.

S = Spiral spring. D = Brass Disc. C C = Contact studs.

central contact wiring before being sent on board, and are all interchangeable in relation to the base blocks, to which they are screwed. A separate main is led direct from the main switchboard to each distributing box, and in large vessels, where transverse bulkheads divide the ship into several water-tight compartments, a distributing box is provided in each compartment, and each may be controlled independently from the engine-room. Where joints are necessary in branch conductors a lead sleeve is laid over the insulation, and soldered to the sheathing of the

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conductor. The special features of such a system of wiring are:—1. There are no joints in the main cables. 2. The number of joints in the branch conductors is reduced to a minimum. 3. The fuses are grouped together in readily accessible distributing boxes. 4. The branch conductors being all of uniform size, the fuses throughout are interchangeable. 5. Switches and fuses are enclosed in watertight cast brass or iron boxes. 6. The lead sheathing of the conductors is soldered at every junction with switches, fuses, or fitting bases, thus insuring an absolutely continuous system.

The methods described above are the outcome of many years' experience of ship wiring, during several of which Messrs. Mavor and Coulson had the co-operation of their late partner, Mr. J. D. F. Andrews. The result as regards mechanical strength, neat appearance, and the high standard and reliability of the insulation attained have ensured the confidence of shipbuilders and shipowners who have had experience of it. Messrs. Mavor and Coulson have carried out several important land installations in Scotland during the last few years with concentric wiring, and would have adopted it much more widely but for the determined opposition of insurance companies, some of whom they have taken much pains to convert. It is to be hoped that insurance companies, who are really only interested from a fire-risk point of view, will soon overcome their prejudices and realise that the concentric system of wiring, when properly carried out, is much more safe than double wiring.

ELECTRICAL COMMUNICATION WITH LIGHTHOUSES.

On Friday last, at the offices of the Board of Trade, Sir Michael Hicks-Beach received a deputation from the Associated Chambers of Commerce of the United Kingdom, on the subject of telegraphic communication with lighthouses. The President was accompanied by Sir Henry Calcraft, K.C.B., Sir George Nares, Mr. Trevor, C.B., and Mr. Walter J. Howell, Private Secretary. The deputation from the Chambers was accompanied by the following Members of Parliament:—Colonel Hill, Mr. F. Roe, Mr. Colman, Mr. Manfield, Mr. C. T. Murdoch, Sir George Elliot, Sir E. J. Reed, Mr. F. B. Grotrian, Mr. Isaac Wilson, Mr. Herbert Gladstone, Sir Albert Rollit, Mr. L. Lyell, Mr. T. Lea, Mr. P. Esslemont, Mr. T. B. Potter, Lord Ebrington, Dr. Farquharson, and Mr. Arnold Morley.

Colonel HILL, in introducing the deputation, said he would read the following resolution of the Chamber of Commerce, and also present the following memorial from that body. The resolution was as follows:—"That in the opinion of this Association it is most important that, in addition to the coastguard stations, the lightships, and lighthouses, both on the mainland and on adjacent islands, such as Lundy Island, be placed in telegraphic communication with the general telegraphic system, and that the Executive Council be requested to take such steps as they may consider expedient to carry this resolution into effect." The deputation came for that purpose. The memorial which he now presented had been drawn up with care, and it was as follows:—"Communication with Lighthouses—To the Right Honourable Sir Michael Hicks-Beach, Baronet, M.P.—The memorial of the Associated Chambers of Commerce showeth, that, inasmuch as a sacrifice of life and property takes place yearly on the coasts of the United Kingdom, owing to the absence of prompt information of ships being in distress or wrecked, it is desirable that a system of telegraphic or telephonic communication be established between coastguard and lifeboat stations, lighthouses and lightships, so far as may be possible or desirable, and the general telegraphic system. Your memorialists would in support of the need of this communication refer to the case of the 'Schiller' wrecked close to the Bishop Lighthouse in 1875, when 331 lives were lost; the lighthouse-keepers saw the wreck, but their signals could not be heard nor seen from the shore. The coroner's jury at St. Mary's, Scilly, found that had the light-keepers been able to communicate with the shore the whole 331 lives would have been saved. Again, in the case of the 'Agnes Jack' off Port Eynon, Swansea, 17 men were lost, after clinging to the masts of their ship for five hours. Had there been telegraphic or telephonic communication with Swansea they would certainly have been saved. And more recently, in 1889, to the case of the ss. 'Lymington,' which was wrecked in February within sight of the Lighthouse at Bull Point, with loss of her crew of eight men, who would all have unquestionably been saved had the lighthouse-keepers been able to telegraph to Ilfracombe for assistance. It would be easy to multiply such cases, but it is well known that they occur from time to time on our coasts. Each minute saved in rendering assistance at shipwrecks is frequently a question of life and death. Your memorialists would point to the fact that in France, Denmark, Norway, Holland, Sweden, Canada, and the Cape, the lighthouses are connected by telegraph and telephone with the general system of those countries. It happens frequently that disabled ships drift helplessly in the sight of rock lighthouses in positions dangerous not only to themselves, but to navigation in general; assistance might speedily be obtained from steam tugs and of neighbouring ports if the lighthouse-keepers had the means of telegraphing for it. During the recent gales, 70 lives are believed to have been lost in the immediate neighbourhood of the Start Lighthouse. Some of the wrecks were seen as they occurred; but the lighthouse-keepers had no means of communicating with the rocket apparatus stations except by messenger. Assistance did not arrive in time to save any of these lives. Your memorialists would urge that the lighthouses on all salient points of the coasts should be put into communication with the telegraph system of the country either by telegraph or telephone. Your memorialists suggest that if such a service of communication were established and administered through the agency of the Post Office a considerable revenue might be raised by means of a scale of charges, which might be made to depend to some extent on the nature of the services rendered to disabled ships, together with fees for the conveyance of ordinary information. Your memorialists would point out that, in the time of war, our outlying rock lighthouses might render the greatest service in conveying information to or from Her Majesty's Navy respecting the movements of an enemy. Your memorialists would urge that if it be possible at once to establish the complete system of communication desired, a commencement might be made without delay at such important points on the coasts as experience may show to be essential. Given under the common seal of the Association this 12th day of June, 1891. Edward S. Hill, President, 1, Great College-street, Westminster, S.W." It was, first of all, thought that this being a matter of national importance involving several public departments, they ought to have approached the Prime Minister upon the subject, but Lord Salisbury suggested that they should come to the Board of Trade, and they were pleased to do so, having a grateful recollection of the kindness, courtesy, and patience of Sir Michael. It could not be denied that disastrous wrecks occurred from time to time around the coasts which were attended with loss of life and a considerable loss of valuable property. The saving of life and property when jeopardised in this manner almost always depended upon the promptitude in which appropriate assistance could be rendered. That assistance existed in all their ports in the shape of steam-tugs and lifeboats at various stations outside the ports, with rocket apparatus and other means. But what was required was some means of letting these stations know that necessity existed for their help. They had a post of observation in their lightships, rock lighthouses, and lighthouses ashore, and in the various coastguard stations which surrounded the coast, but they had no means of communication with them. They asked that the deficiency should be supplied, and that those posts of observation should be placed either in telegraphic or telephonic communication with the telegraphic system of the country. There might be difficulties, which, however, might not be insurmountable. In carrying this out an estimate had been made that £100,000 would suffice, but whether that estimate was correct or not he would say that even the expenditure of a very much larger sum would be justified if the lamentable loss of life could be prevented. It would be a great advantage to the commerce of the country that they should have accurate and prompt information of the movement of vessels, and in time of war it would be most invaluable both to the naval and military authorities. Other countries enjoyed these facilities, and a great country like ours should not be behind-hand. Sir Michael had suggested that they should give a list of the names of certain points on the coast where communication with the telegraphic system of the country was most needed, and those points were:—St. Agnes, Scilly, Start, St. Alban's Head, Dungeness, North Foreland, Cape Clear, Flamborough Head, Rattray Point, South Stock, St. Anne's and Lundy Island. Sir Michael might not be able to carry out all this immediately, but a commencement might be made in the national interest, and a saving of life and property might be effected and correct information might be obtained both for commercial, naval, and military purposes.

Sir ALBERT ROLLIT advocated the necessity of having the Spurn Light in communication with the shore.

Mr. BAYLEY, of Plymouth, gave several instances; the case of the "Schiller," the "Lymington," the "Agnes Jack," and the "Mexico," where, if there had been communication with the mainland, the lives of their crews would have been saved.

Captain POMEROY (Cardiff) having spoken,

Mr. JOHN R. WIGHAM (Dublin Chamber) said he came, at the request of the Dublin Chamber of Commerce, to ask Sir Michael to give his best attention to the memorial which had been handed in. The view of the Dublin Chamber was that the whole of the

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dangerous coasts of the country should be connected together, and put in telegraphic communication with the lighthouses, so that in the event of shipwrecks assistance might be obtained. The Commissioners of Irish Lights, with whom the Dublin Chamber has been in communication, had informed them that it would be an incalculable advantage if telegraphic communication could be made over the great headlands, so that the different stations could be put in direct communication with the telegraphic system of the country. The Chamber of Commerce were interested in what was useful for the shipping interest, but they were also interested in the more important question of the saving of life; and on the general question he would say that the mercantile community of Ireland, and especially that part of it represented by the Chamber of Commerce in Dublin, were exceedingly strongly in favour of the memorial, and anxious that some steps should be taken to remedy the disastrous state of things that existed at present.

Mr. Esslemont, M.P., Mr. Grotrian, M.P., Mr. Bulteel (Plymouth), and Mr. Lyall, M.P. (who advocated the necessity for further provision being made for the north and west coast of Scotland), having spoken, Sir Michael Hicks-Beach replied as follows:—I should like, if I could, to be quite clear as to that part of the subject with which it is possible for me to deal. I do not understand that you come to me to-day to suggest that this communication should be established for the purpose of trade. Lloyds, of course, now undertake the signalling for that purpose, which is fair for all those whom it concerns, and I think it ought to be so. And, in addition, there is the strongest evidence on the part of those who have inquired into the subject and are well qualified to speak as to the impolicy, at any rate, of entrusting such duties to men in lighthouses who have pretty well enough to do in the ordinary way to look after the lights. If you take up their time which ought to be occupied in that way, for the purpose of signalling ships for trade purposes, I think it would be a great evil. All that you ask me to consider to-day, I understand, is the question so far as affects the saving of life in cases of wreck. Then I would ask you in turn to understand that I really can have nothing to do departmentally with the matter so far as it affects the Coastguard Service. The Coastguard are, of course, under the Admiralty, and any fresh duties to be imposed upon them would be imposed with the consent of the Admiralty, and under rules to be made by the Admiralty. The expense connected with the Coastguard stations and the telegraphic service generally is, I think, one which ought to be borne, if it were done, by the Treasury, and therefore you should approach the Treasury, and not me, upon such a subject. What I have to do with lighthouses and lightships, and the only fund I can dispose of, as you are aware, is the Mercantile Marine Fund. Now, one of the speakers has already alluded to the experiment which has been made in this matter with regard to the Sunk Lightship. I think a cable was established between the Sunk Lightship and the mainland for something like four years, and the result of that was that a Committee, composed of Lord Crawford, Sir Edward Birkbeck, Sir George Nares, Mr. Trevor, Mr. Sydney Webb, Sir Thomas Sutherland, Captain Hozier, and Mr. Alfred Holt, reported that although the experiment had shown that electrical communication could be established even in such positions, yet that the experiment should be discontinued as really having been of no service. I should say that Sir Edward Birkbeck dissented from the discontinuance of the experiment, but in his reservation he thought that a more extended trial should be made for the further period of not less than five years, and that the cost should be met by direct vote from Parliament. All the other members of the committee reported that the experiment should be discontinued, and Sir Edward Birkbeck joined with them in declining to advise that electrical communication should be established with outlying lighthouses and islands, with the special purpose of saving life at sea. Now that is the position of the case at present. You wish that the experiment should not only be taken up again, but that it should be very largely extended, and, in fact, my recollection of the short discussion of the subject at the meeting of the Chamber of Commerce is this: That there was a desire that electrical communication should be applied to practically all lighthouses and lightships. I felt that that was impossible, and I asked you for a list which you have been good enough to give me. I should like, I confess, to have some further evidence that those whose contributions form this Mercantile Marine Fund desire that this work should be done. Colonel Hill, and all of you, are aware, of course, that it comes from the Light Dues which are paid by the shipping interest. Now, you represent, no doubt, to some extent the shipping interest, but not to such an extent as other organisations which exist; and I call your attention to the fact that two gentlemen, Sir Thomas Sutherland and Mr. Alfred Holt, who certainly are very representative men in the shipping interest, reported that in their opinion the Sunk experiment should be discontinued and no further experiments of the kind should be made. The request you have made to me to-day that this should be done, to some extent in certain places, at the cost of the Mercantile Marine Fund, would, I think, come to me more strongly if it were backed by those who pay. I do not know whether Colonel Hill could undertake to answer to-day for the Chamber of Shipping, but perhaps he might have the matter brought before them.

Colonel Hill said that he thought the shipping interest would probably not be averse to making some contribution.

Sir Michael Hicks-Beach: I am not asking for a moment that the Light Dues should be increased in order to bear the cost of this experiment, because, as I say, you do not ask me to-day for a very large expenditure. You merely ask, as I understand, that electrical communication should in certain places be established and that the matter should be further tried.

Colonel Hill said that there was a very strong feeling that this was a matter of such great national importance that they might fairly ask the Treasury to undertake it.

Sir Michael Hicks-Beach: Then I must ask you to go to the Chancellor of the Exchequer and persuade him to give you a grant for that purpose. But I am perfectly confident what his answer would be to me if I were to make such a proposal to him. All that I have to deal with in the matter is the Mercantile Marine Fund.

Colonel Hill said that, knowing that several departments were involved, they thought it desirable to go to the Prime Minister, who represented them all, and they now came to Sir Michael, at his suggestion. He hoped that if they succeeded in convincing him, possibly he would communicate with the other branches of the Government.

Sir Michael Hicks-Beach: I tell you frankly that I am disposed, seeing the strong feeling that there is among many persons very much interested in this matter, to pursue the experiment somewhat further. I do not think it is enough to take the experiment on the Sunk Lightship as definitely concluding any action in the matter, and I should be perfectly willing if the shipping interest were willing that, at any rate in some of those places (of course they would have to be considered by my department, and by the lighthouse authorities), or in some other places, measures should be taken for establishing communication even at the expense of the Mercantile Marine Fund. I do not think that I can say anything further that will show you more conclusively that I am in sympathy with you as far as I can safely go. But I should be very glad if your request to me to-day to make these experiments in certain places were backed up by the Chambers of Shipping.

The deputation then withdrew.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

MONDAY, June 22nd.

London Chamber of Commerce.

3 p.m. Meeting of the Committee of the Electrical Trades Section at Botolph House.

THURSDAY, June 25th.

Chemical Society.

8 p.m. Extraordinary General Meeting.

FRIDAY, June 26th.

Physical Society of London.

5 p.m. Ordinary Meeting. Papers to be read: (1) "The Construction of Non-Inductive Resistances." By Prof. W. E. Ayrton and T. Mather. (2) "The Influence of Surface-Loading on the Flexure of Beams." By C. A. Carus-Wilson. (3) "On Pocket Electrometers." By C. V. Boys. (4) "On Electrification due to the Contact of Gases with Liquids." By J. Enright.

Royal Institution.

9 p.m. Faraday Commemoration Lecture. By Prof. Dewar F.R.S

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

A New Combustible.—A successful experiment was recently carried out at Rome with a new combustible. It is a preparation of lignite, of which there are very rich deposits in Italy. A train was run from Rome to Frascati, and ran easily up one of the steepest gradients of Italy. The quantity of fuel used during the transit was 367 kilogrammes, as against 300 of ordinary coal. The train was a heavy one of eight carriages and luggage van, and there were 70 passengers. The smoke from the new combustible is very light, and not disagreeable in odour.

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The Electrician.

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THE FARADAY CENTENARY.

It is rather discomposing to have to associate the idea of centenary with the name of FARADAY. He and his achievements belong so intensely to our own day that it is a shock to begin to memorialise him as belonging to the past. It may be held better in general to commemorate the maturity and the climax of a man's life rather than his birth, which at the time of its occurrence is usually a particularly obscure event. The year 1687 is the date to be commemorated in connexion with NEWTON, the date of the appearance of the Principia. If the date of the discovery of magneto-electricity is sufficiently definite that probably would be regarded as the climax of FARADAY'S life.

Many potentially great men, probably, are born, but the hardship of circumstances is too severe for most of them, and we only discover or get the benefit of a few. Nature is proverbially wasteful, and not more of genius than of anything else is she likely to be specially economical if we leave her alone. But it behoves us to regulate and modify nature, in this as in so many other respects, and in process of time so to ameliorate the common lot as to give every human being a chance of developing what good and great things there are in him. It has, we fear, to be admitted that the interference of man with nature in this particular direction, at least since the rise of great towns, has not even tended in any beneficent direction, but rather the contrary. Recently, however, the direction of effort has been more encouraging—more enlightened; and in the matter of primary education, at least, we may hope before long to be able to hold our heads up once more among the nations,

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instead of patiently admitting inferiority. For secondary education at the present time very little good can be said. It, too, must before long be taken in hand, and the terrific waste of life and opportunity, consequent on the incompetent system of teaching and the scientific ignorance of the class from which secondary teachers are drawn, must be checked. In higher education we are all right, or, at least, if we err it is in a totally different direction. It suffers from no lack of competent teachers. We retain the highest men we have got for the purpose, and keep them at it for most of their lives; not hesitating to provide the President of the Royal Society with a permanent class of raw juniors who need instruction in elementary matter they might just as well and should have learnt at school, if only secondary schools and schoolmasters were what they ought to be. We get our great men and we waste them. NEWTON we put to look after our coin! It was doubtless the most valuable thing we had about us, and hence it was quite appropriate to utilise the greatest scientific man of all the ages as master of our beloved Mint. But it is a perennial sarcasm.

The career of such a man as FARADAY teaches many things, among others these two:— 1. Take care of your obscure children, and never despise a human being, unless he has shown himself despicable after he has had a fair chance. 2. When a man has come to the top and shown that he is of sound judgment, strong character, bright genius, and steady industry, do not waste these qualities by employing him in trivial or frivolous pursuits. He may teach a little, but don't waste all his life in teaching, especially not in teaching up to a standard suitable to a school. Above all things don't use him to make money, either for himself or for other people. Money may be the test of success in business; it is no test of success in science. A livelihood a man must earn; but the less of his energies that go that way, the better. FARADAY, with splendid wisdom, took his life into his own hands, and did not drift, as it is so easy to do. He decided that his life should be simple and his wants few, that he might have the more time for his chosen pursuit. The rest the founders of the Royal Institution did for him. "Here," they said practically, "is a place where you need not teach, where your laboratory will not be incommoded with students, but where you may work in peace. We will provide you with some rather dingy and small rooms, we will give you apparatus in moderation, and will pay an assistant, whom you must teach to be competent. If you are satisfied with a modest salary, here you may spend your life, devoting it entirely to original investigation; except occasionally, when you will be expected to come out of your shell and tell us about what you have been doing. We shall come, some of us, only to have a quiet snooze after dinner, or to see some pretty experiments; but the experiments after all are part of nature, they please you as much as, or more than, they please us, and you won't mind showing them. Moreover, we can tell you this, that if only you have got something good to say and know how to say it intelligibly, all the best men of the country and many of other countries, will come to hear you, and your audience will not be limited to fashionable ladies and gentlemen, though these will be by no means excluded." The Royal Institution has done more for British science than it knows. It has provided a home for a succession of distinguished men whose names are, or soon will be, household words; it has also set an example which will one day be followed, either by private endowment or by State aid, and other homes of research will spring up among us, as we now find budding, here and there, a few centres of higher education.

Of FARADAY'S work, Lord RAYLEIGH and Prof. DEWAR remind us in this and the following weeks; and it is well to recall the chemical side of his work as well as the more purely physical. The liquefaction of gases, a process which has now advanced a long way towards pe fection, we owe to him, as well as the effect of magnetism on light and the production of electricity from magnetism. But, after all, it is the life more than the work that has the greatest charm for us. Other men can work; not every man can worthily live. And when a man of genius lives a clear, calm, contemplative, serene, and dignified existence in the midst of this bustle and feverish activity, in the world and not of it, he conveys a lesson, quite unintentionally, to all future generations of his race, which may well stimulate ingenuous youth to aim higher and to live more simply. His life constitutes a service to his country and to mankind, the memory of which the world will not willingly let die.

TELEGRAPHIC COMMUNICATION WITH LIGHTHOUSES.

The result of the deputation which was received by the President of the Board of Trade, on Friday last, on the subject of telegraphic communication with our lighthouses, if result it can be called, was fairly satisfactory. A deputation to a Government department rarely expects to receive a definite assurance that its prayer will be granted, but, on the other hand, it seldom meets with an unqualified rejection. One of the reasons why it is so difficult to "get something done" in this case is, that it is by no means an easy task to discover the right department to approach. The memorial, which we print in another column, "showeth, that, inasmuch as a sacrifice of life and property takes place . . . it is desirable that a system of telegraphic or telephonic communication be established between coastguard and lifeboat stations, lighthouses and lightships, . . . and the general telegraphic system." No Government Minister of Public Safety is appointed to act in conjunction with the "sweet little cherub that sits up aloft," and we must be content to watch that the broad principle of humanity, which cannot be said to pertain to any one department, is endangered by none. But as the petitioners pointed out that property was sacrificed as well as life, Sir MICHAEL HICKS-BEACH was not slow to refer them to LLOYDS, who take care of trade matters. When coastguards were referred to he had to direct them to the Admiralty; when lighthouses were alluded to they were reminded that the keepers "have pretty well enough to do in the ordinary way to look after the lights," and when telegraphic service was mentioned, Sir M. HICKS-BEACH was of opinion that the cost of it ought to be borne by the Treasury, and therefore, said he to the deputation, "you should approach the Treasury, and not me, upon such a subject."

Consisting as it did of practical men, the deputation, had foreseen that several departments were involved, and, recognising the difficulty of divided responsibility, had taken the sensible course of approaching Lord SALISBURY. He recommended them to go to the President of the Board of Trade, and this recommendation, while not saddling the latter with any moral obligation or bounden duty, drew from him a most satisfactory expression of sympathy. He admitted that the single experiment on the Sunk Lightship was not definitely conclusive, and volunteered the information that the only fund of which he could dispose was the Mercantile Marine Fund, which relies on the light-dues paid by the shipping interest. While it is true that the matter is one which closely concerns the shipping interest, it has a far wider importance, both from a humane and from a national point of view. The well meant, but partially efficient, Plimsoll rules,

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and the other requirements of the Board of Trade, are examples of State interference to which the most ardent individualist will not object. Such opposition as the rules met with, useful as it may have been in preventing fussy fads, was inspired by no high motives, and there are many men who would rather increase their insurance premiums than swell the Mercantile Marine Fund by larger contributions. But where life is lost, property, too, is generally forfeited, and while the former consideration has claims on the State, the latter concerns the proprietors, from whom some contribution towards the expenses may therefore be justly demanded. But the national aspect of the matter is twofold, the apparently incompatible objects aimed at being, as we have observed on a former occasion, the saving of life by telegraphic connection between lighthouses and lifeboats, and the early destruction of life by affording timely information to our naval commanders. The Treasury has only to give the word, and the Post Office, who have long ago made the necessary estimates, would rapidly complete the work, or at least connect up a dozen or so of the more important points.

ELECTRIC AND MAGNETIC THEORIES.

BY JOHN T. SPRAGUE.

Before replying to Prof. Silvanus Thompson I must have a word with Mr. Oliver Heaviside. He has more than once suggested to me a "receptive spirit" in the study of these hypotheses; and on p. 95, in remarks evidently meant for me, speaks of the "obstruction evidenced by a carping and unreceptive spirit." Will he explain why we should manifest this "receptive" spirit? Why are we called upon to do like the children, "open our mouths and shut our eyes" and swallow what anyone offers us? I have always understood that the true scientific spirit of investigation, where hypotheses are the subject, is one of candid scepticism; that the law is—prove all things, hold fast that which is true or proved.

§ 1. I hold a theory developed from the whole work of the past the labours of all our great electricians, it agrees with every fact of nature, explains every fact in accordance with the principles of all the related branches of science. I find a new theory proposed, which overturns all our past work, which leaves experimental facts to base itself upon mere hypotheses about the properties of a substance whose very existence is unprovable; I ask for facts and am given mathematical symbols; at the utmost I am offered the assertion that Hertz has proved anything needed, though I can see nothing in what he has done which is not clearly intelligible quite apart from these hypotheses. To slightly change Mr. Heaviside's own words, § 65, "when I, as a critical thinker, look through these investigations and hypotheses, I see that they are purely artificial elaborations, devoid of physical significance, groping after mares' nests, in fact." Why bring a receptive spirit, then? I believe them to be thoroughly mischievous inventions, opposed to all true science, and I will do my best to oppose them, in the interests of genuine inductive science.

§ 2. Prof. Thompson begins (§2, p. 44) by asking me whether I have "evidence of any case in which there is transfer of energy that cannot be accounted for by the hypothesis of a lateral transfer through the medium." Of course he means electric energy; as our general experience of transfer of energy requires a material agent, I consider that we ought logically to require evidence that such a transfer ever occurs apart from such an agent. He must not call on me to find evidence; but I am ready to answer him. I have no evidence of any single case of transfer of energy as a flux through the medium at all. He has altogether omitted the real question at issue. He has dealt (in the way of evidence) solely with the phenomena of the variable periods. The real point in debate is how energy is transferred by an electric *current*. I ask him, has he *any evidence* of a single case of lateral transfer during the existence of true current? It is notorious that there is no scrap of evidence. Therefore he avoids this difficulty by a logical dodge. He says, practically, if I can show that there are *some* cases in which we must agree that energy is transferred through the medium, I am entitled to assert that it is so in all cases. Bad logic and worse science. He omits the fundamental circumstance that the conditions are entirely different. Where energy is transferred, we find only a temporary action, clearly of the nature of a static stress, which only transmits the energy needed to establish the stress, and returns it when the stress-producing conditions cease to exist. He has, therefore, no title whatever to claim, without evidence—and against actual evidence—that transfer of energy can be effected by the medium when the conditions are those of a continuous flux instead of a static stress, and the energy is not returned.

§ 3. More especially has he no title to claim for his hypothesis any superiority over the older theory, which recognises the essential difference of the two conditions, and clearly explains both. But the only experimental evidence which Prof. Thompson offers is to demonstrate certain well-known facts, which any theory must take into account, and which I fully treated in my articles. I am disappointed. It is a pleasure to read Prof. Thompson's writings when dealing with real things. Then he moves steadfastly, and makes all thing clear; but it is very different when he is attempting to give substance to shadows, and convert make-believe hypotheses into science. He must excuse me if I pull his argument to pieces.

§ 4. In the first place he has taken up the proverbially dangerous position of sitting upon two stools. He poses as the champion of one definite assertion, viz., that the energy of the source goes direct from the source, *viâ* the medium; that the conductor—the circuit plays no part in *transmission* of energy, but only receives it *from the medium*, acting as a waste pipe to serve some inscrutable purpose.

§ 5. But the only thing which he proves, and bases his subsequent argument upon, is that energy is transmitted *from the conductor*, not from the source; (when he shows it going from the source, he does not prove, he only exercises his fancy). I warned him beforehand that his Proposition V. involved this consequence; in it he speaks of "transfer of energy through the medium *from the primary circuit* to the secondary." But the very basis of his proper argument is that the energy does not go from the source into the circuit at all, but from the source direct to its work.

He has taken great pains in his figures, 1—5, to prove my case, and contradict his own doctrines. Let us first study those figures and his reasoning. Fig. 1, p. 44, shows a source connected to primary coil A, and a similar parallel coil B connected to a galvanometer G. It is really identical in principle, though altered in form, with my Fig. 8. As it happens it will enable me to demolish Prof. Thompson's argument better than my own does. For just consider: What is the process of transmission? Prof. Thompson, leaning on one of his stools, kicks over the other, the passage of energy from the source: he adopts my own view, that it travels, first *viâ* the wire to A, then "in some way" from A to B, and then *viâ* B to G. Now, what is the *modus*—the some way? No one knows better than he, and yet Prof. Thompson ignores the simple truth, that it is by the setting up of magnetic lines of force, which thread both his coils, and that, therefore, the energy, dependent upon the ampere-turns of A, must come from A and *not* from the source direct.

§ 6. I say he ignores the magnetic *modus*, and I will prove this by his Fig. 5 (p. 65), where he shows the two coils connected in series, and gives us arguments valid only if we ignore the fact that it is by magnetism set up in the medium, and not by any direct transfer of energy from wire to wire, still less from source to wire, that the phenomena are produced. Just let me knock the bottom out of the tambourine on which he plays his pœan in G. In Fig. 1, with the coils insulated, A generates magnetic lines, which, traversing B, set up a stress and momentary current in its wire manifested as work in G. I explained all this on the other theory in my §§ 66—69. In Fig. 4 he shows the current produced

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in both A and B, connected in series as one, and triumphs in the excess spark, etc. Of course he has doubled his magnetism; in Fig 5 he opposes the coils in series, and again triumphs. Well, he has simply neutralised the magnetism, and therefore diminished the storage of energy. I do not wonder that he sees that these phenomena are "compatible with the notion of propagation of current by longitudinal forces." True he says, "*if taken by themselves.*" I am content to take them any way, but I seek in vain for any evidence that they are compatible with, or explainable by, the notion of lateral or other transfer *from the source.* At all events Prof. Thompson does not even pretend to give it.

§ 7. It is the same with Figs. 2 and 3, both show transfer *via* the circuit; the only "medium" taking part in it is the space between the two agents, the inducing and induced circuits. The only evidence really given is that of energy traversing the conductors, at the spark space B, in Fig. 2; and in the copper plate B, in Fig. 3. No one doubts that energy has passed by a stress in the medium. But how does it reach the "medium," that is the space between A and B? Prof. Thompson *shows* it as passing from A, to which conductors convey it from the source, as I say; but he *says* it reaches B from the source (at least that is the only meaning I can attach to the theory) and is altogether silent as to the functions of A, or how the energy is first got to A.

§ 8. He is worse than silent, for (of course, unintentionally) he misrepresents my position on this subject. He says, § 14, p. 105: "To ask how the energy knows where it is wanted is trifling with the question." He also compares my question to an imaginary absurdity of his own device.

I submit that my question is *the* question, the point on which the whole theory turns. Prof. Thompson says energy goes direct from the source; he and all his side say that this energy is propagated in the same manner as light is; that electricity and light are identical in essence, varying only in length of wave or something of that sort. Well, light is radiant, and has no special directive power. It is not trifling to demand from these hypothesisers an explanation (it only needs to invent a new property of the ether) of what agency controls the direction. I know what it really is; it is the circuit, the conductor. But those who deny this must substitute something else. The search for a "waste pipe" will not do, because while there may be 1,000 equally suitable dispersers attainable, the energy will select the one which completes the circuit, and that only, except during the variable period, when it exerts a special but still localised action.

§ 9. But Prof. Thompson also misrepresents facts when dealing with what he calls "a most misleading statement" of mine, viz., that electric energy is linear and controlled, while light is radiant and uncontrolled *except by an outer agency.* Now, these words in italics involve the whole argument, and show us something which cannot be evaded. Prof. Thompson and his friends must show us what it is which guides the energy, and transforms it from radiating lines into locally directed lines. My question is not a ridiculous one, as he pretends, but an imperative one. Why does the energy go to the *wire*, as the hypothesisers assert? The circuit wire conducts nothing, not even an impulse: why does this radiant energy seek that wire and follow it 1,000 miles away through any amount of twistings? Very like the transmission of light that, is it not?

§ 10. Now, as to trifling with the question, I must really ask Prof. Thompson to say if he does not do this in his § 2. Is it really scientific argument to talk about what might have been our perceptions or conceptions if our existence had been conditioned by an ocean of quicksilver instead of air? If it be the fact (I have suspected it for some time) that these new theories are really applicable only to an altogether suppositious universe, say, of *n* dimensions, in which all our familiar truths are converted into unrealities, and actual nonsense becomes solid truth, I should respectfully make use of the waste basket. Life is too short and too full of serious realities to waste time over journeys with "Alice in Wonderland" in search of truth. We do live in an atmosphere of air, and surrounded by dielectric matter, and not by a conductor. That, then, is the condition upon which we ought to base our conceptions; if the difficulties of the new theory are, as we are now told, the natural inevitable result of this environment of thought (and air), I suppose we must wait to clear them up until we find ourselves in the more favourable state of living in a bath of quicksilver. Possibly the new theories may be true in mercury, but we want them proved here, and I do not see that we have yet moved a single step towards that result.

§ 11. Let us go back to Figs. 1 to 5. In Fig. 1 the two coils are placed parallel to each other; let B be turned, so that it is at right angles to A. No effect would be produced. Why not, if it is a mere question of collecting energy in a radiant state, whether from A or from the source? The wire would equally present equal and similar surface to the rays, and be equally fitted to serve as that "sink" or waste pipe. But the magnetic lines would not traverse the space in B, and could not develop the current which is measured by G. But now replace the air core common to A and B by an iron core; it makes no difference whether the coils are parallel or at right angles, *i.e.*, whether the core is straight or curved: the magnetic lines traverse both coils, and now G will testify to the momentary current alike in both positions.

In Fig. 3 we are furnished with the proof (positive, not merely negative) that the constant current does not transmit energy, which guessers might say it does, only our apparatus does not show it. Heat is developed in B by an alternating current in A, because of the successive momentary currents set up in the copper plate B. A steady current in A produces no heat in B, because there is no current in B; but now move B about while that current exists, and we have heat and mechanical resistance; the last due to disturbance of the lines of force, not of energy, and the consequent motion of the molecules of A while rearranging themselves in the lines of force; the energy does not come *via* A, but is mechanically applied to B in the effort to move it among the lines of force. In Fig. 4 we have the two coils connected in series, generating double magnetism in their one air core, and therefore double reactions of energy. In Fig. 5 we have them arranged to produce opposite currents, and therefore a magnet with consequent poles, absorbing only half the energy and giving up very little, because the magnetism will react in the core itself instead of externally.

§ 12. Let us now examine the attempt to deal with the case of constant current, p. 103, Figs. 6—11. I have two objections to make: 1. The figures and the argument are wholly imaginary; no scrap of evidence is given, or can be given, that they correspond to any natural facts. 2. They do not cover the whole facts, and they misrepresent the facts, so far as these can be known and tested. I must ask my readers to closely follow my analysis of Prof. Thompson's argument. He says there is nothing in the way of proof "that energy is transmitted by an end thrust along the wire of the circuit." But there is this evidence, that in the wire we know something is going on; that which we call current—but the nature or direction of which matters nothing to this argument; be it what it may, *it is there;* the energy does actually *issue from the wire as heat;* we know that; it is a mere guess that it first enters the wire without evidencing its presence in the space it is asserted to traverse.

Now, consider Figs. 8 and 9, or, as it is the prettiest and most imaginative, let us take 8; are we to be told that those dotted curves represent, in the smallest degree, the known facts; is it not known that whatever occurs in the enclosed space occurs equally outside that space; that if energy crosses from source to circuit by those paths, similar paths surround the whole wire? Instead of a nice circle, clear of obstructions, let that wire go about in all sorts of fashions, as real circuits do —the symmetry, the apparent reasonableness, of those dotted lines vanishes at once.

13. Now I come to the question which is said to trifle with the subject. What guides these lines of energy into all sorts of convolutions, and links their paths from the source to the wire? *It is the question;* and, moreover, the new theory gives no answer. If the energy leaves the zinc surface, and becomes radiant, exactly as light is, what gives to it a definite direction, independent of straight lines, which light unquestionably does

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not possess? No electrical theory is of any service which does not include this dual action with unity of nature. In the wire theory we have this, the action starts in the wire in both directions; that was proved long ago by Wheatstone's spark experiment; it is proved by the certain fact that a complete closed circuit must be provided to permit true current to be maintained. Why should it be necessary on the sink theory? Cut the circle of Fig. 8 at each figure. Why should not space 5—6 serve as sink to source, 5—6 irrespective of the others, if it is really true that the energy goes as shown?

In what way does Fig. 8 explain the phenomena of so-called "potential," if each cell does act independently in the manner said to be "rational" in §12? In what manner does the theory explain the relations of energy to the dynamic, magnetic, and chemical actions of what we call current? I invite the other side to take my Fig. 5 and explain, on their theory, the several actions and dissipations of energy, which I have clearly and simply explained on the conductor theory. They cannot do it; at all events no one has ever yet done it. Prof. Thompson says, §11, "any theory which merely takes into account the flow of current, and neglects the distribution of electric potential, is obviously incompetent to deal with the question how the energy is propagated." Does he mean to imply that the old theories do this? Can he mean, in face of my Fig. 5, that I have not taken this into account? How does he do so in Figs. 8 and 9; do they show any reason why his cells in series give a higher potential, when he actually makes them deliver their energy (which is potential) in parallel, to what are practically separate sinks? In return, I say no theory is of any value which waives these fundamental facts:—

1. A closed conductive circuit, which is essential.
2. A medium which takes up stresses only, *i.e.*, a dielectric.
3. An action related to the equivalence and structure of matter.
4. The functions of energy, mechanical and chemical, in the circuit.
5. The functions of energy in the dielectric.
6. The "danger of attempting to extend hypothesis beyond the limits of actual observation" (your Editorial, p. 73).

§14. Now contrast Figs. 8 and 9. Wherein lies the difference of direction of the energy lines? Simply in the difference of conductance in the wire circuit. Again I ask—how does the energy, radiating (like light) from the zinc surfaces, know where to direct its path, which light never does? "flowing outwards into space and swirling round." Now, will Prof. Thompson illustrate this? Will he show us any instance of a motion once set up, swirling round, except under some new force? That is what I want defined. Why does it swirl? What swirls it? It moves contentedly enough in my wires. The equipotential paths and parallels do not explain, because the energy itself creates them.

Then there is this curious fact: it goes mostly where there is least conductance, there being the same current everywhere. We are told, p. 13, "just enough going to any given part to keep up the radiation of heat from that part." As a fact to be explained, yes: but why? the energy produces the heat. The energy wants a waste pipe, and curiously enough goes mostly to the worst waste pipe, where there is least material to dissipate it. Certain assertions are made at end of §14, true enough as facts, but not as explanation, because they do not distinguish cause and effect. We have radiant energy from zinc to wire, across medium; radiant energy as heat from wire back into medium; electric potential, set up by energy at the zinc, of course, and variable equipotential lines due to resistance in the wire, which wire is only a sink, all in a lump; sometimes cause, sometimes effect, just as you please. Still worse, we have it proved that the electric potential increases as taken through the cells, proving an action of energy in the linear circuit, and then this fact absolutely dismissed, except in the vague term potential, and the separate cell action invented.

§15. Prof. Thompson says that the non-relation of energy to current and its relation to the non-conductance, *i.e.*, resistance of the circuit, is "itself a ground for thinking that the path of the current is not the same as the path of the energy." But this is exactly what happens in mechanics, in all cases of friction. I defy any one to give any intelligible reason why in Fig. 9 the energy should nearly all go to the thin line, as shown, or explain the sympathy between energy radiant at the zinc, and needed (for no particular purpose except to transmit a current, itself of no particular use) at parts of the wire. The conductor theory is simple; the current which originates at the source means a molecular motion. Where the wire is thinnest those motions must be most rapid; rapid motion, greater friction, consumes more energy in waste heat, and the energy transmitted pays toll as it goes, just as a caravan does when passing through different territories.

I now invite Prof. Thompson to make his Fig. 9 into a fact, and show us the passage of energy; it is easily done, if the thing exists; let him place a glass pan, containing bisulphide of carbon, or other suitable liquid, and prove by polarised light the existence of these lines of stresses corresponding to the alleged energy streams. I suppose he knows as well as I do that he will not get them, as he ought to do, but will get evidence of the cross stresses of magnetism instead, if the current is strong enough; at all events, he will get nothing at all resembling his imaginary lines.

§16. No test will manifest any action within that space, except the lines of static stress between any two points, such as that shown a, a', Fig. 9; but these have no relation whatever to transfer of energy direct from the source; and what they prove is that energy is present at every part of the circuit, within it, and ready for an outlet. This also has nothing to do with the enclosed space, for the electrometer may be 1,000 miles away, and will act just the same as if in the middle of the space, proving, beyond dispute, that the energy has travelled from the wire circuit, and that the conductors carry energy and produce electric stress, or potential, 1,000 miles away. In fact, there is no experimental proof existing of the passage of energy, during constant current, across the medium, the real point in debate, while every use made of electric currents is practical evidence of transmission of energy by the circuit.

(*To be continued.*)

PROF. PERRY'S ELECTRIC SUPPLY METER.

Those who peruse the list of new patents have been made aware that Prof. Perry has for some time been engaged in the construction of a new meter, and our French contemporaries have illustrated and described the instrument, from patent specifications, as though it had been *un fait accompli*. The meter, in a practical form, and with nearly all the latest improvements, was shown for the first time at the soirée of the Royal Society on Wednesday last. Prof. Perry informs us that he has always been of opinion that, although any man with a knowledge of electricity and mechanism could invent an instrument to integrate current or energy, it was impossible, by going outside the two principles enumerated by Prof. Ayrton or himself in 1883, to obtain a simple, that is, a cheap, lasting, and accurate supply-meter. These two principles were—(1) let electro-magnetic forces quicken or slow the time of a clock, and (2) use an electro-motor, and let its motion be retarded by forces proportional to the velocity. Such forces are fluid friction when the motion is very slow, and resistance due to Foucault or eddy currents.

The present meter works on the second principle, but it has to be observed that the conditions are not simple. First, if there is more than the merest trace of ordinary solid friction in the motor, as this alters with time and other circumstances, even if balanced by a constant current torque, it destroys the accuracy of the motor. Hence the pivoting must be excellent, and all solid friction of brushes or rubbing contacts must be avoided.

Second. If mercury cups are used as brushes, two errors are introduced. The nature of the contact alters rapidly with time, the mercury getting oxidised and dirty. If anything dips into mercury there is a friction between it and the mercury at the surface which is really of the nature of a solid friction and not a fluid friction.

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Again, it seems impossible to do away altogether with ordinary fluid friction. Now, at slow speeds, fluid friction follows a law which is just what is wanted, but this is not the case at high speeds. Again, it alters considerably with temperature and other conditions.

There are experimenters who have wasted thousands of pounds because they have assumed that fluid friction is proportional to the square of the speed. Now, this is the case only at high speeds, and a meter runs at all sorts of speeds. The highest speed of this meter is one revolution per second, and this is when 100 amperes are passing through it, and even at this highest speed the fluid friction follows a law not very different from proportionality to speed. When these instruments are being manufactured by well-devised and accurate machinery their very highest speed will be a crawl.

The meter exhibited is the outcome of much thought and experiment. The solid, or *quasi* solid, friction is very small; the fluid friction is still much greater than is desired, but it

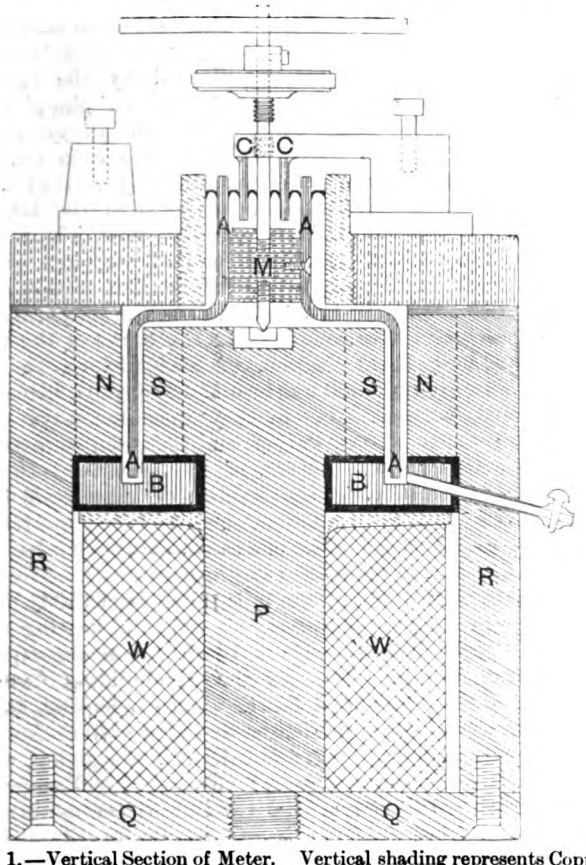

Fig. 1.—Vertical Section of Meter. Vertical shading represents Copper, diagonal shading, Iron; the space filled with Mercury is left white, the upper surface being shown by the rounded outlines.

follows a law which is nearly right, as the speeds are small, and, besides, *all other resistance is completely masked* by an enormous Foucault current resistance. It required a considerable amount of calculation and experiment to determine just the best method of making this resistance as great as possible.

The field of the motor being F, and the current through the armature C, the turning moment is proportional to F C. The resisting moment is a small, nearly constant term a, due to solid friction; a term $b\,n$, due to fluid friction, in which n is the number of revolutions per second (b cannot be relied upon to keep quite constant, except at very small speeds), and a very important term $c\,F^2\,n$, representing the Foucault current friction, on which great reliance may be placed. We have then—

$$F\,C = a + b\,n + c\,F^2\,n,$$

or,

$$C = \frac{a}{F} + \frac{b}{F}\,n + c\,F\,n.$$

It is, therefore, obvious that by making F as great as possible the terms $\frac{a}{F}$ and $\frac{b}{F}\,n$ become less important in comparison with $c\,F\,n$.

That this result had been attained was evidenced by the great slowing of speed of the meter for a given current when the field was increased. In use, the field magnet is sufficiently saturated to make an alteration of a few volts at the field-magnet terminals of very little effect.

Fig. 1 is a section. A is the armature; it is a cylindric copper vessel, closed at its upper end, except for a few holes. It is like an inverted claret glass, and is immersed in mercury, in which it revolves. It receives current from a heavy ring, B, of copper, the current passing through the mercury to the lower edge of A. It passes in a cylindric current sheet upwards through A, and passes from A through the mercury to C, a fixed tube dipping into the mercury. At this upper part there is a quasi-solid friction, but it is very small. The armature is coated with insulating varnish everywhere, except at the places where it receives and gives out current, and at these places it is nickel plated; hence, in the field there is no current whatever through the mercury. A phosphor bronze spindle gives motion to the counting arrangement. The spindle is in two pieces, so that the upper part may be insulated. It can be fixed rigidly to the fixed bracket when being carried about. M is ebonite. S P Q R N is a cylindric or tubular magnet wound with fine wire, W. The cylindric poles, S N, form the two sides of the trough in which the armature revolves, and 7 or 8 watts are expended in maintaining between them an intense magnetic field. But this field is not uniform. The plan of the pole pieces, Fig. 2, shows a number of wooden plugs, between which iron poles project, so that every portion of the cylindric part of the armature passes from intense field to almost no field 10 times in every revolution, and the result is that the Foucault current friction is about 25 times the fluid friction

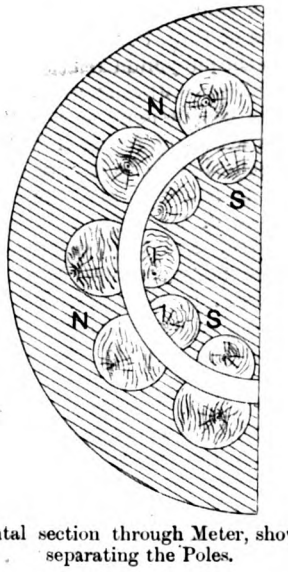

Fig. 2.—Half horizontal section through Meter, showing Wooden Plugs separating the Poles.

In such an instrument, the smaller the clearance thicknesses inside and outside A, the more exact will the intrument be in its record. It can be shown that the best results are obtained when the thickness of the copper is equal to the two clearances. Until the meter is manufactured in considerable numbers the clearance will be much greater than it ought to be. In the instrument exhibited the copper was much too thin and the clearance much too great, and yet:—

1. It started with 0·2 ampere. This represented the error due to solid friction.

2. From 2 amperes to 100 amperes there was only one place (namely, at 10 amperes) where the error was so great as 1 per cent.

3. There was nothing to alter with time.

4. Temperature errors balanced themselves.

In the patent list in *The Electrician*, Vol. X., p. 730, of December 23, 1882, is illustrated the meter of Faure, in which a copper bell dips into mercury. This is the earliest meter which depended for its action on the rotation of mercury, or

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of a conductor suspended in it. In a patent of Edison, in 1883, the identical arrangement is to be found. The development of this idea most familiar to our readers is the Ferranti meter. Here a quantity of mercury is set in rotation, and this motion is imparted to the recording train by vanes which take up its motion, as do the ebonite vanes in the Siemens water meter. Foucault currents are absent from the Ferranti meter. Again, the uniformly distributed, but varying magnetic field of the Ferranti meter, depends on a series winding through which the main current flows, and the friction is balanced by a shunt winding. In Prof. Perry's meter, on the other hand, the field is maintained by a shunt coil, it is not uniformly distributed, and is practically constant in strength.

The working and the theoretical accuracy of the Perry meter is the outcome of the practical study of the phenomena of fluid friction. Ever since Stoke's classical work on the viscosity of fluids, fluid friction has been treated by many mathematicians as being simply proportional to speed. This was Stokes' discovery, and is true for small speeds. Engineers, on the other hand, starting from hydraulic experiments, and the resistance offered to vessels propelled through the sea at several miles an hour, have always assumed that fluid friction varies as the square of the velocity. The apparent discrepancy was finally settled, as it should be, by a beautifully simple experiment of Osborne Reynolds's, who showed that a submerged jet of coloured water flowing into a tank issued in a mere line at low speeds, and at a certain definite point broke up, owing to the formation of eddies. As soon as the motion thus becomes turbulent, the friction being made up of viscosity and of eddies is practically proportional to the square of the velocity. Such is the importance of accurate knowledge of mechanical forces in the construction of electrical instruments that we must give a brief account of the further investigations of Prof. Perry on the fluid friction, since they bear directly on the subject before us. The friction in this meter is practically all pure fluid friction, and, the speed being so small, it is directly proportional to the velocity. Prof. Perry has found that when a body is partly immersed in mercury the friction at the surface—that is to say, at the line of contact—between the body, the mercury, and the air is of the nature of solid friction. One of the copper bells of his meter, suspended by a fine steel wire, and partly immersed in mercury, as in the Faure meter, rotated through, say, one turn, and then left, will stand in that position for hours, since the quasi-solid friction acts at a considerable leverage; but if the surface of the mercury be raised, so that the whole bell is immersed, the friction takes place only round the spindle, and at so small a radius that it is negligible. This quasi-solid friction, we understand, appears to be independent of the length of the line of contact, just as ordinary solid friction is independent of surface, but the radius at which it acts is all-important. It is satisfactory, therefore, to know something about this quasi-solid friction, since it determines the serious matter of the starting current, and Prof. Perry is confident that the 0·2 ampere at which his meter begins to move is well outside the limit which will be attained in practice.

THE ELECTRICAL MANUFACTURE OF PHOSPHORUS.

The large and increasing demand for phosphorus, not only for its main use, viz., the manufacture of matches, but for its subsidiary applications in the organic syntheses which form one branch of modern chemical industry, and in the production of many of the phosphor-alloys that have recently come into vogue, has made the question of its economical production of much commercial importance, as well as of technical interest.

On considering the method of manufacture at present generally employed, it becomes evident that the chief cost lies less in the raw materials than in that of the plant and labour necessary for the production of phosphorus from them. The outline of the process is simple and may be told in few words. Some form of calcium phosphate—formerly bones were used, but mineral phosphates are now preferred—is treated with sulphuric acid, the liberated phosphoric acid separated from the calcium sulphate produced at the same time, by filtration, the solution of the former concentrated by evaporation, mixed with charcoal and heated strongly in small retorts. The carbon reduces the phosphorus from its oxide, and it, being volatile, distils, and is condensed in the usual way. As in the manufacture of sodium by the old process of reducing sodium carbonate with carbon, the chief objection to this method consists in the high temperature necessary to effect the reaction, and in the loss of a portion of the product (phosphorus in this case) through cracks in the retorts, the frequent renewal of which is also costly. The loss of phosphorus in this way is increased by the circumstance that the operation is conducted at a pressure slightly above that of the atmosphere, on account of the exit from the retorts being provided with a water-seal.

In a recent article we pointed out that there were many indications of a growing application of a principle which we then enunciated, namely, that of applying heat to the centre of a mass of material, the temperature of which it was necessary to raise for the purpose of effecting some chemical reaction, by means of an arc formed at the required spot, and instanced the Cowles furnace, and the process adopted by the Electrical Construction Corporation for the manufacture of phosphorus, as cases in point, at the same time indicating the advantages that accrued from such an arrangement. Since then Dr. Readman, of Edinburgh, who had independently arrived at the same idea as Messrs. Parker and Robinson, of the Electrical Construction Corporation, and who has now joined forces with them, has made public the details of his large scale experiments in a Paper read before the Scottish section of the Society of Chemical Industry, and published in its journal. His earlier experiments were conducted at the works of the Cowles Company (Limited), at Milton, in Staffordshire, the large dynamo there, giving 5,000 amperes at 50-60 volts, being available for that purpose. Before they were far advanced he became aware that Messrs. Parker and Robinson were working in the same field, and the upshot of the agreement that was come to between them, was the erection of large scale experimental works near Wolverhampton, where a site of about ten acres has been obtained on the banks of a canal, and upon it have been put up boiler and engine-houses and furnace-sheds. The power is supplied by three Babcock and Wilcox boilers of 160 H.P. each, having a grate area of 30 square feet and total heating surface of 1,619 square feet, worked at 160lb. A triple expansion torpedo-boat engine by the Yarrow Shipbuilding Company, capable of generating 1,200 I.H.P. when condensing, and 950 when worked without a condenser, and an Elwell-Parker alternating dynamo absorbing over 500 I.H.P., and giving, as may be desired, 5,000 amperes at 80 volts, or 2,500 amperes at 160 volts, when running at 300 revolutions per minute, have been set up. The dynamo is excited by an Elwell-Parker shunt wound machine, delivering 90 amperes at 250 volts when running at 800 revolutions per minute, a portion of the current being available for lighting and experimental work.

The process is quite simple, consisting merely in feeding in the raw materials, passing the current between suitable electrodes, as in the Cowles furnace, and collecting and condensing the volatilised phosphorus in the usual way. The weight of the slag amounts to about half the original raw materials, and can be tapped at the bottom of the furnace, while fresh raw materials are fed in at the top, so that the process is continuous, and, it is expected, may be run for days without intermission. No trouble from the escape of phosphorus vapour is to be apprehended, as the walls of the furnace may be as massive as is requisite, seeing that the heat is applied in the interior and has not to penetrate from without. It is claimed that the charges can be made to have as high a content of phosphorus as 15 per cent., and that the slag may be obtained with as little as 1 per cent., while as much as 86 per cent. of phosphorus actually passes into the condensers. The crude phosphorus thus obtained is of satisfactory quality, and can be purified by fusing under water, squeezing through washleather, and treating with ammonia, and afterwards with chromic acid mixture in the usual way.

The use of basic slag as a cheap phosphoric material has been tried, but without success, as the iron it contains forms a

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phosphide corresponding, approximately, to the formula $Fe_2 P_3$, and containing 23-24 per cent. of phosphorus, thus leading to serious loss. Although, as already indicated, the furnaces are, with the exception of the addition of the necessary condensing arrangements, similar in construction to the Cowles, yet, on account of the need to diffuse the heat evenly throughout them, it is found advisable to limit the size considerably, those actually in use being capable of turning out about 1½cwt. of phosphorus apiece per day.

The question of the electrodes used is naturally interesting, as these subsidiary but indispensable adjuncts, sometimes prove more costly than is at first anticipated. Those made by the Cowles Company cost about 8-10 shillings each, but the Electrical Construction Corporation are using gas carbon, which is considerably cheaper.

It will thus be seen that though the work done hitherto is of the nature of an experiment, yet the experiment is on so large and well-ordered a scale that it has more nearly reached the position of a manufacturing process than many inventions introduced far more pretentiously to public notice ever do.

The key to its successful operation is, we are convinced, to be found in the adoption of the principle of applying heat in the very spot where its usefulness is greatest, doing away at one stroke with the clumsy practice of external firing at present employed in this as in many kindred industries.

It is to be noted that nothing of the nature of electrolysis takes place. The current is alternating, and the sole reason for its use is its capability of conversion into heat at any desired place. The development of this principle, and its application to manufacturing processes of the most diverse kinds, may be confidently expected at no distant date.

THE CAUSTIC SODA AND CHLORINE SYNDICATE.

Once more has the time-honoured scheme of making chlorine and caustic soda—the two commodities the production of which keeps the Leblanc process in a state of precarious vitality—been brought forward with flourish of trumpets and a florid prospectus, and has arrived at the stage of its statutory general meeting.

With the strictly financial aspect of the case we have little to do, but from an electro-chemical point of view there are some points that may interest our readers.

Until quite recently the electrolytical critic was hampered by the fact that the Syndicate was formed to take over and work an invention for which the vendor had only obtained provisional protection. The original documents being thus denied him, he had, perforce, to content himself with information of somewhat less satisfactory authenticity. The specification, however, has now been published, and a little additional information on the nature and prospects of the process can be obtained from it.

Taking in the first place, however, that which is common property, and has been put forward by the Syndicate as the justification for its existence, and studiously refraining from in any way "going behind" the statements in the prospectus, we find that, with the exception of the figures showing the oppressive profits of the Salt Union and the Chemical Union and those dealing with the purchase of the vendors' rights, the character of this document is, in chemical language, purely qualitative. It is pointed out that the new process will save two-thirds of the salt and a considerable amount of fuel and labour, that it will require smaller premises, cheaper and less complicated plant, and a shorter time than the old, advantages which are capped by another, viz., that "the entire process is simultaneous, simple, and direct, whereas by the existing methods a whole cycle of operations are required to produce the chlorine and caustic soda separately." Simultaneity, simplicity, and directness, though appealing powerfully to one's artistic instinct, are by no means necessarily of industrial value. The confusion of mind which leads to the acceptance of the fallacy that these qualities are of importance in themselves, is precisely of the same nature as that which causes the condemnation by the unthinking of a piece of mechanism as complicated when it is in reality only complex. This claim cannot, therefore, be accepted as necessarily constituting an important merit of a successful manufacturing process.

Examining the other statements quoted above, and postponing the consideration of the first, namely, that less salt is used, to be dealt with in the light of other assertions to which we shall presently refer, we may say then on *á priori* grounds it is reasonable to suppose that less labour and smaller premises may suffice, and that the plant would be simpler, but that the alleged saving of fuel is not self-evident, and that, therefore, it must be accepted with considerable reserve. These are the conclusions at which anyone well acquainted with the subject would arrive by the exercise of his own intelligence, and they, therefore, need no elaboration, and may be dismissed with the remark that an estimate, even if admittedly approximate of the economies to be effected, would be in every way preferable to loose *ex parte* statements.

Those who think as we do in this matter would naturally look for some definite account of experimental work upon which the foregoing assertions are based, and would, therefore, turn naturally to the report of Messrs. Cross and Bevan upon the process, which is incorporated in the prospectus. And here it may be well to meet an objection which is commonly made to reports of this kind, and has been to our knowledge advanced in this particular instance. Persons better acquainted with manufacturing processes than with the principles upon which they rest are often guilty of condemning an experimental investigation into, or demonstration of, a new process, on the ground that it has been conducted on a small scale. Such a contention scarcely needs serious refutation; those who are familiar both with the conduct of large-scale operations, and with the method of executing those experiments by which their success has been secured, know very well that the mode of ascertaining the best lines upon which to work, which is at once handiest, cheapest, and most instructive, consists in the device and execution of an experimental investigation, directed, not to the slavish reproduction of the conditions of manufacture, but to the elucidation of the difficult and doubtful points that have to be encountered and overcome in any considerable and novel undertaking of the kind. Premising the acceptance of this view by the majority of our readers, we may proceed with our criticism of Messrs. Cross and Bevan's report of their experiments which have been, we believe, conducted on a laboratory scale.

In the first place, that ancient delusion and snare, a working model, appears to have been used, and a kind of toy manufactory set up. The scientific interest of the process, and the originality of the invention, is apparently centred in an article known as a "Special Diaphragm." It is true that it is stated to be "perfectly efficient in separating the products of the (why "the"?) electrolysis, soda and chlorine," and to introduce a resistance which is satisfactorily low, the difference of potential between the terminals never exceeding five volts. Unfortunately nothing is said as to what proportion of the five volts is necessary for overcoming the resistance of the diaphragm, and what for effecting the work of electrolysis, or, in plainer terms, what percentage of the total available energy is consumed by passage through the diaphragm.

In the report of the statutory general meeting repeated reference is made to the merits of this diaphragm, which is said to have given rise to no trouble or difficulty, although expected, even by the patentee, to do so. The chief information tendered on that occasion was the assertion that "the principle of its construction is based on a well-known pneumatic law." Assuming the verbal accuracy of this report, the difficulty of divining from it the nature and functions of a diaphragm of this description is considerably enhanced. According to the specification, the diaphragm consists of a series of V-shaped troughs, built up one within the other, and the spaces between them packed with asbestos fibre or steatite. The *raison d'être* of this arrangement is not obvious, and its exact relation to the "well-known pneumatic law" is equally obscure. It is also difficult to see why, if asbestos be chosen on account of its fibrous character, as is apparently the case,

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steatite should be mentioned as a possible substitute. If steatite, why not powdered slate, kaolin, firebrick, or some other similar material refractory to the attack of the products of electrolysis? Steatite possesses nothing in common with asbestos save its chemical composition, the physical difference between the two being great. One has only to consider the eminent adaptability of asbestos as a packing material and the equal excellence of steatite for the jets of gas-burners, to realise the gulf that divides them. We feel compelled to call particular attention to all that concerns this part of the invention, as it appears certain, both from the nature of the process and by the special stress laid upon it by the patentee, that the degree of novelty and efficiency of the diaphragm will largely determine the success of the process technically and financially.

One further piece of information was communicated to the meeting referred to above which cannot be wholly overlooked in a consideration of the possible future of the invention. This is the statement that an anode has been devised which is far better than any of its forerunners. It is to be regretted that no inkling of the nature of this anode was given, as the attainment of one that is at once cheap, of high conductivity, and sufficiently refractory to resist the disintegrating effect of the products of electrolysis in high degree, would be a considerable achievement.

In order to gain some idea of the particular merits of this anode, reference must again be made to the specification itself. There it is stated that the anode consists of a copper or other metal substructure, to which the carbon, after having been coppered, is soldered. No doubt by this means good conductivity at first is obtained, but as no method is mentioned of protecting the union thus formed from corrosive influences its continued utility seems improbable. The same process may be adopted for the cathode, but a similar objection applies, though in less degree. It is true that at the statutory meeting reference was made to a recent improvement in the anode, but, beyond the vague general statement that some such improvement had been effected, no information bearing upon this point was forthcoming.

Passing to the remainder of the statements of the prospectus, we find it is alleged that the yield of caustic soda and chlorine is "70 per cent. of the theoretical, a satisfactory efficiency," but whether this means that 70 per cent. of the total salt is decomposed, or that 70 per cent. of the total energy is utilised, or that the bleaching power and causticity of the products of electrolysis are 70 per cent. of that demanded by theory, is left in obscurity. This is the more important, as we believe Messrs. Cross and Bevan advanced somewhat peculiar views in the case of the notorious Hermite process, as to the bleaching efficiency of the liquor produced thereby, maintaining, if we recollect rightly, that its power of decolourising fibre could not be gauged by any method of estimating its oxidising power by titration with such a common-place re-agent as arsenious acid, and claiming for it exemption from ordinary methods of chemical criticism. This ambiguity appears to have struck even the writers of the report, for in another clause they reiterate the 70 per cent. claim, with the additional information that it applies to the electro-chemical efficiency of the process. The precision of this statement is a little marred by its juxtaposition with the remarkable assertion that this efficiency is attained with "a *resistance* of not more than 5 *volts* per cell." (The italics are ours.) The meaning is, of course, obvious, but the looseness of phraseology casts a doubt upon other statements unprovided with their own criteria. The report recommends a demonstration of the system by means of a 40 H.P. installation.

At the statutory meeting the usual disclaimer and apology was made by the Chairman, who had little to say, and his position was backed up by the inventor, who has never "heard of a new process being demonstrated before the statutory meeting was held." Mr. Greenwood, while alluding to the wonderful new anode referred to above, and to fresh patents, did not bring forward any additional information, in the absence of which the only scientific attitude to adopt towards them is that of suspended judgment

THE FARADAY CENTENARY.

On Wednesday afternoon last, at the Royal Institution, Lord Rayleigh delivered a lecture in connection with the celebration of the centenary of Faraday's birth. The Prince of Wales presided, and amongst those present were:—Sir G. Stokes, Sir W. Thomson, Sir H. Roscoe, Sir William Grove, Sir F. Abel, Sir Frederick Bramwell, the Lord Mayor and Lady Mayoress, Sir A. Geikie, Sir Benjamin Baker, Sir Joseph Lister, and Sir F. Galton.

The PRINCE OF WALES, in opening the proceedings, said: I can well remember that two-and-twenty years ago I had the high privilege of presiding at a meeting here. Among others present on that occasion I remember were Sir Edward Saville, Sir Roderick Murchison, Sir Henry Holland (a very old personal friend), Dr. Bence Jones, and many others whom I recollect, but some of whom have now passed away. The object of our meeting on that occasion was to select a suitable memorial to the memory of the great Faraday. You are well aware that the fine statue by Foley, which is down in the hall below, was, we thought, a suitable memorial to the great man. As for myself, personally, I feel proud to think that in the days of my boyhood my brother and myself used to attend his chemical lectures here at this Society. We can ever remember the admirable and lucid way in which he delivered those lectures to us who were mere boys, and gave us a deep interest in chemistry, which we kept up for many years. I can only regret now that I have not the time to pursue that interesting science. To-day is a memorable day, as this year we celebrate the centenary of the birth of that great man, and I think all of us have every reason to feel grateful that two such eminent men as Lord Rayleigh and Professor Dewar have consented to give lectures on the works of Faraday. I have now only to ask Lord Rayleigh if he will give us his address.

Lord RAYLEIGH said that the man whose name and work they were met to celebrate was identified in a remarkable degree with the history of that Institution. If they could not take credit for his birth, they could in other respects hardly claim too much, for during 54 years Faraday found there his opportunity, and, for a great part of the time, his home. The simple story of his life must be known to most present. Fired by contact with the genius of Davy, he volunteered his services in the laboratory of the Institution; Davy, struck with the enthusiasm of the youth, gave him the desired opportunity, and, as had been said, found in Faraday not the least of his discoveries. The early promise was indeed amply fulfilled, and for a long period of years, by his discoveries in chemistry and electricity, Faraday maintained the renown of the Institution and the honour of England in the eyes of the civilised world. He should not attempt in the time at his disposal to trace in detail the steps of that wonderful career; the task had already been performed by able hands, and in their own "Proceedings" they had a vivid sketch from the pen of one whose absence to-day was a matter of lively regret. Dr. Tyndall was a personal friend who had seen Faraday at work, and had enjoyed opportunities of watching the action of his mind in the face of a new idea. All that he could now aim at was to recall very shortly some of Faraday's great achievements, and, if possible, estimate the position which they held in contemporary science.

Whether they had regard to eventual scientific import or practical results, the first place must be assigned to the great discovery of the induction of electric currents. He proposed first to show the experiment in something like its original form, and then pass on to variations with illustrations from the behaviour of a mode whose mechanical properties were strictly analogous. It was one of the great difficulties of his task that Faraday's discoveries were so fundamental that they had become familiar to all students of physics. The first experiment required them to establish in one coil of copper wire an electric current by completing the communication with a suitable battery; that was called the primary circuit, and Faraday's discovery was this: That at the moment of the starting or stopping of the primary current in a neighbouring circuit, in the ordinary sense of the words, completely detached, there was a tendency to induce the current to start. He had said that those two circuits were perfectly distinct, and they were distinct in the sense that there was no communication between them, but, of course, the importance of the experiment resided in this, that it proved that in some sense the circuits were not distinct; that an electric current circulating in one does produce an effect in the other, which is propagated across a perfectly blank space occupied by air, and might equally well have been occupied by vacuum. It might appear that that was a very simple and easy experiment, and of course it was so in a modern laboratory, but it was not so at the time when Faraday first made it. With all his skill, Faraday did not light upon truth without delay and difficulty. One of Faraday's biographers thus wrote:—"In December, 1824, he had attempted to obtain

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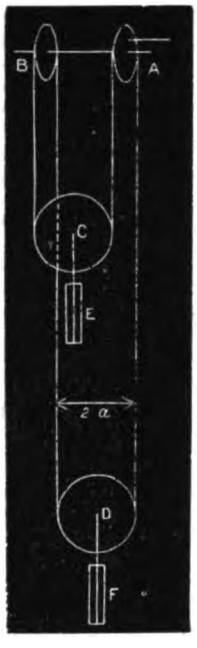
an electric current by means of a magnet, and, on three occasions, he had made elaborate and unsuccessful attempts to produce a current in one wire by means of a current in another wire, or by a magnet. He still persevered, and on the 29th August, 1831, that is to say, nearly seven years after his first attempts, he obtained the first evidence that an electric current induced another in a different circuit. On September 23rd, he writes to a friend, R. Phillips, "I am busy just now again with electro-magnetism, and think I have got hold of a good thing, but cannot say ; it may be a weed instead of a fish that, after all my labour, I at last haul up." We now know that it was a very big fish indeed. Lord Rayleigh proceeded to say that he now proposed to illustrate the mechanics of the question of of the induced current by means of a model (see Figure), the first idea of which was due to Maxwell, being a combination known as Huygen's gear, invented by him in connection with the winding of clocks. Two similar pulleys, A, B, turn upon a piece of round steel fixed horizontally. Over these is hung an endless cord, and the two bights carry similar pendant pulleys, C, D, from which again hang weights, E, F. The weight of the cord being negligible, the system is devoid of potential energy ; that is, it will balance, whatever may be the vertical distance between C and D. Since either pulley, A, B, may turn independently of the other, the system is capable of two independent motions. If A, B, turn in the same direction and with the same velocity, one of the pendant pulleys, C, D, rises, and the other falls. If, on the other hand, the motions of A, B, are equal and opposite, the axes of the pendant pulleys and the attached weights remain at rest. In the electrical analogue the rotatory velocity of A corresponds to a current in a primary circuit, that of B to a current in a



secondary. If, when all is at rest, the rotation of A be suddenly started, by force applied at the handle or otherwise, the inertia of the masses E, F, opposes their sudden movement, and the consequence is that the pulley B turns *backwards*, *i.e.*, in the opposite direction to the rotation imposed upon A. This is the current induced in a secondary circuit when an electromotive force begins to act in the primary. In like manner, if A, having been for some time in uniform movement, suddenly stops, B enters into motion in the direction of the former movement of A. This is the secondary current on the break of the current in the primary circuit. The analogy of the two things was absolutely essential. So far was this the case that precisely the same argument and precisely the same mathematical equations proved that the model behaved in the way in which they had seen it behave in the experiment. That might be considered to be a considerable triumph of the modern dynamical method of including under the same head phenomena, the details of which might be so different as the impulse or relative currents. If they had a current which alternately stopped and started, and so on, for any length of time, they, as it were, produced in a permanent manner some of the phenomena of electrical induction ; and if it were done with sufficient rapidity it would be evident that something would be going on in the primary and in the secondary circuit. The particular apparatus by which he proposed to illustrate those effects of the alternating current was devised by a skilful American electrician, Prof. Elihu Thompson, and he had no doubt it would be new to many. The alternating current was led into the electromagnet by a suitable lead ; if another electric circuit, to be called the secondary circuit, was held in the neighbourhood of that, currents would be induced and might be made manifest by suitable means. Such a secondary circuit he held in his hand, which was connected with a small electric glow lamp. If a current of sufficient intensity were induced in that secondary circuit it would pass through the lamp, which would be rendered incandescent if it were of sufficient strength. (*Illustrating.*) It was perfectly clear there was no conjuring there ; the incandescent lamp brightened up. One of the first questions which presented itself was, what would be the effect of putting something between? Experimenting with a glass plate, he showed there was no effect, but when they tried a copper plate the lamp went completely out, showing that the copper plate was an absolute screen to the effect, whatever it might be. Experiments of that kind, of course in a much less developed and striking form, were made by Faraday himself, and must be reckoned amongst some of his greatest discoveries.

Before going further, he might remark on what strong evidence they got in that way of the fact that the propagation of the electric energy which, having its source in the dynamo downstairs, eventually illuminated that little lamp, that the path of the electric energy was not merely along the wires, but was capable of bridging over and passing across a space free from all conducting material, and which might be air, glass, or, equally well, vacuum. Another effect, something like the same kind, of a striking nature, devised by Prof. Elihu Thomson, consisted in the repulsive effect which occurred between the primary current circulating around a magnet and the induced current in a single hoop of aluminium wire. Illustrating this by experiment, he showed that the repulsion was so strong as to throw the wire up a considerable height. Those effects were commonly described as dependent upon the mutual induction between two distinct circuits, one being that primarily excited by a battery or other source of electricity, while the other occurred in a detached circuit. Many surprising effects, however, depended on the reactions which took place at different parts of the same circuit. One of these he exhibited by the decomposition of water.

About the time of the experiments of which he had been speaking were made, Faraday evidently felt uneasiness as to the soundness of the views about electricity held by his contemporaries, and to some extent shared by himself, and he made elaborate experiments to remove all doubt from his mind. He re-proved the complete identity of the electricity of lightning and of the electricity of the voltaic cell. He evidently was in terror of being misled by words which might convey a meaning beyond that which facts justified. Much use was made of the term "poles" of the galvanic battery. Faraday was afraid rather of the meaning which might be attached to the word "pole," and he introduced a word since generally substituted, "electrode," which meant nothing more than the way or path by which the electricity was led in. "Electric fluid" was a term which Faraday considered dangerous, as meaning more than they really knew about the nature of electricity, and as was remarked by Maxwell, Faraday succeeded in banishing the term "electric fluid" to the region of newspaper paragraphs.

Diamagnetism was a subject upon which Faraday worked, but it would take him too long to go into that subject, though he must say a word about it. Faraday found that whereas a disc of iron or nickel or cobalt, when placed near a magnet or combination of magnets, would be attracted to the place where the magnetic force was the greatest, the contrary occurred if for the iron was substituted a corresponding mass of bismuth or many other substances. The experiments in diamagnetism were of a microscopic character, but he would like to illustrate one position of Faraday's, developed years afterwards by Sir Wm. Thomson, and illustrated by him in many beautiful experiments, only one of which he now proposed to bring before them. Supposing they had two magnetic poles, a north pole and a south pole with an iron ball between them, being free to move along a horizontal line, then, according to the rule he had stated, the iron ball would seek an intermediate position, the place at which the magnetic force was the greatest. Consequently, if the iron ball be given such a position, they would find it tended with considerable force to a central position of a equilibrium ; but if, instead of using opposite poles, they used two north poles, they would find that the iron ball did not tend to the intermediate position, because that was not the position in which the magnetic force was the greatest. At that position there was no magnetic force, and one completely neutralised the action of the other. The greatest force would be a little way out, and that, according to Faraday's observations, systematised and expressed in the form of mathematical law by Sir Wm. Thomson, was where the ball would go. (*This was illustrated by experiment.*)

The next discovery of Faraday to which he proposed to call attention was one of immense significance from a scientific point of view, the consequences of which were not even yet fully understood or developed. He referred to the magnetisation of a ray of light, or what was called in more usual parlance the rotation of the plane of polarisation under the action of magnetic force. It would be hopeless to attempt to explain all the preliminaries of the

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experiment to those who had not given some attention to those subjects before, and he could only attempt it in general terms. It would be known to most of them that the vibrations which constituted light were executed in a direction perpendicular to that of the ray of light. By experiment he showed that the polarisation which was sufficient to pass the first obstacle was not sufficient to pass the second, but if by means of any mechanism they were able, after the light had passed the first obstacle, to turn round the vibration, they would then give it an opportunity of passing the second obstacle. That was what was involved in Faraday's discovery. As he had said, the full significance of the experiment was not yet realised. A large step towards realising it, however, was contained in the observation of Sir William Thomson, that the rotation of the plane of polarisation proved that something in the nature of rotation must be going on within the medium when subjected to the magnetising force, but the precise nature of the rotation was a matter for further speculation, and perhaps might not be known for some time to come.

When first considering what to bring before them he thought, perhaps, he might include some of Faraday's acoustical experiments, which were of great interest, though they did not attract so much attention as his fundamental discoveries. He would only allude to one point which, as far as he knew, had never hardly been remarked, but which Faraday recorded in his acoustical papers. It related to a phenomenon capable of observation which he described on the seashore, that if during a strong, steady wind on a smooth sandy shore with enough water on it from a receding tide, there might be observed in the place where the surface was not broken by stones, the water suddenly undulates, leaving waves with ridges which were not parallel to the course of the wind. When he first read that statement, many years ago, he was a little doubtful as to whether to accept the apparent meaning of Faraday's words. He knew of no suggestion of an explanation of the possibility of waves of that kind being generated under the action of the wind, and it was, therefore, with some curiosity, that some two or three years ago at a French watering place he went out at low tide, on a suitable day when there was a good breeze blowing, to see if he could observe anything of those waves described by Faraday. For some time he failed to observe the phenomenon, but after some time he was perfectly well able to recognise them. He mentioned that as an example of Faraday's extraordinary powers of observation, and even now he doubted whether anybody but himself and Faraday had ever seen that phenomenon.

Many matters of minor and theoretic interest were dealt with by Faraday, and reprinted by him in his collective works. He was reminded of one the other day by a lamentable accident which occurred owing to the accidental breaking of a paraffin lamp. Faraday called attention to the fact, though he did not suppose he was the first to notice it, that, by a preliminary preparation of the lungs by a number of deep inspirations and expirations, it was possible so to aërate the blood as to allow of holding the breath for a much longer period than without such a preparation would be possible. He remembered some years ago trying the experiment, and running up from the drawing-room to the nursery of a large house without drawing any breath. That was obviously of immense importance, as Faraday pointed out, in the case of danger from suffocation by fire, and he thought possibly the accident to which he alluded might have been spared had the knowledge of the fact to which Faraday drew attention been more generally used.

The question had often been discussed as to what would have been the effect upon Faraday's career of discovery had he been subjected in early life to mathematical training. The first thing that occurred to him about that, after reading Faraday's works, was that one would not wish him to be anything different to what he was. If the question must be discussed, he supposed they would have to admit that he would have been saved much wasted labour, and would have been better *en rapport* with his scientific contemporaries if he had had elementary mathematical instruction. But mathematical training and mathematical capacity were two different things, and it did not at all follow that Faraday had not a mathematical mind. Indeed some of the highest authorities had held (and there could be no higher authority on the subject than Maxwell) that his mind was essentially mathematical in its qualities, although they must admit they were not developed in a mathematical direction. With these words he would conclude: "The way in which Faraday made use of his idea of lines of force in co-ordinating the phenomena of electric induction shows him to have been a mathematician of high order, and one from whom the mathematicians of the future may derive valuable and fertile methods."

Sir William Thomson moved a cordial vote of thanks to Lord Rayleigh for his delightful lecture, which was seconded by Sir George Stokes, and was carried unanimously.

Lord Rayleigh briefly replied.

Sir Frederick Bramwell read letters from Prof. Tyndal and other gentlemen expressing their regret at not being able to be present, and introduced to the Prince of Wales several distinguished foreign *savants* who had been elected members of the Institution. The Prince of Wales delivered the diploma of membership to the newly-elected members, and the proceedings closed with a vote of thanks to the Prince for presiding.

Amongst the distinguished foreign *savants* upon whom the honorary membership of the Institution have been conferred are MM. Berthelot, A. Cornu, Mascart, and Louis Pasteur; Profs. Bunsen, von Helmholtz, von Hoffmann, and Virchow; Profs. J. P. Cooke, Dana, and Simon Newcomb, of the United States; Profs. Canizzaro and Tacchini, of Rome; Prof. Thomsen, of Copenhagen; Prof. Thalen, of Upsala; Prof. Mendeleef, of St. Petersburg; Prof. Marignac, of Geneva; and Prof. Van der Waals.

A STUDY OF THE PLANTÉ LEAD-SULPHURIC ACID-LEAD PEROXIDE CELL, FROM A CHEMICAL STANDPOINT.*

PART I.

BY G. H. ROBERTSON.

The author, in the introduction, states that though, since Frankland in 1883 published his first "Contribution to the Chemistry of Storage Batteries," the capabilities of the Planté cell have been well tested and are now thoroughly understood, there is still considerable uncertainty as to the precise nature of the chemical changes which attend their use; and that it was principally to study the part played by the electrolyte that the investigation the results of which are recorded in this Paper was instituted about a year ago at the Central Institution, at Dr. Armstrong's suggestion, as McLeod's observations on the electrolysis of sulphuric acid solutions led to the supposition that the changes occurring in the acid were probably less simple than was commonly supposed. This supposition was verified.

The first section of the Paper deals with the nature of the lead salt formed during discharge. It is pointed out that, as is well known, red lead varies considerably in composition, generally containing a smaller proportion of peroxide than is represented by the formula $Pb_3O_4 = PbO_2 2PbO$; and that with nitric acid it behaves as though it were a mixture of the two oxides, the nitric acid always dissolving out the monoxide. There is no reason why sulphuric acid should not behave similarly, and, since lead sulphate is but very slightly soluble, red lead may be expected always to yield a corresponding sulphate, *i.e.*, a mixture of peroxide and sulphate, containing an amount of sulphate corresponding to the amount of monoxide originally present in combination with the peroxide. At Dr. Armstrong's request a number of experiments were made at the Central Institution (long prior to the reading of Messrs. Gladstone and Hibbert's Papers) by two students, Messrs. Briggs and Ingold, on various samples of red lead, with the result that the sulphate formed always corresponded to the monoxide originally present.

As no proof of the existence of a definite homogeneous sulphate corresponding to red lead can be afforded by analysis alone, evidence must be obtained that the product differs in some of its properties from a mixture. It was to be expected that the E.M.F. of an oxysulphate would differ from that of a corresponding mixture of sulphate and peroxide, and have some definite value; therefore pastes were made of peroxide of lead, peroxide of lead and sulphate, in the proportions of 1 to 1 and 1 to 2, and also from the product obtained by treating red lead with dilute sulphuric acid (1 to 5). Experiments made with these pastes showed that there was a difference of degree only between the red lead pastes and the mixtures, and that the lowering of the E.M.F. appeared to depend rather on the intimacy of the mixture, and consequent thorough coating of the peroxide granules with sulphate, than on the proportion of sulphate present. Mr. Desmond Fitzgerald had already shown, in 1887, at the Institution of Electrical Engineers, that the mere admixture of lead sulphate with peroxide of lead produces a lowering of the E.M.F.

With regard to Frankland's observations respecting the colour of the product formed on the peroxide plate during discharge and the reducibility of the sulphate, the author points out that the colour is due to the incomplete reduction of the peroxide, owing probably to the almost complete blocking up by lead sulphate of the pathways by which the current travels through the electrolyte in the paste; that careful examination of the plugs from a discharged cell shows that the base consists of practically unaltered peroxide of lead, and that the surface, which is rich in $PbSO_4$, is really a mass of partially reduced granules of peroxide of lead which are coated with sulphate. Also, though pure lead sulphate is very difficult to reduce, it is very well known that mixtures of lead sulphate and peroxide of lead, or other conducting substances, are reduced with comparative ease, and

* Abstract of a Paper read before the Royal Society, June 11, 1891.

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it is very intimate mixtures of this nature which have to be dealt with as a rule in charging a cell.

In conclusion, the author points out :—

That neither chemical nor electrical tests give any ground for supposing that any other sulphate than the ordinary white $PbSO_4$ is concerned in the interactions occurring in the cell.

That were the sudden lowering of the E.M.F. caused by a change in the nature of the chemical compounds formed on the plates, it is very difficult to account for the very rapid recovery of the E.M.F. exhibited by an apparently discharged cell.

In the second section the electrolyte is dealt with, and, after referring to the work of Berthelot, Richarz, Schöne, Traube, and others on the electrolysis of sulphuric acid solutions, the author describes experiments made to test the effect of the addition of sodium sulphate to the electrolyte, as, from information received from Mr. Barber Starkey, it seemed probable that the different behaviour of cells containing sodium sulphate was due to the catalytic action of this salt on the hydrogen dioxide always found in electrolysed acid of the strength used in batteries, and which is probably formed by secondary action from persulphuric acid.

Mr. Preece most kindly aided the investigation by allowing experiments to be carried out at the General Post Office, where one-half of the secondary cells contain 1 per cent. of sodium sulphate and the other half ordinary dilute acid, specific gravity 1180. He also put at the disposal of the author the records of the behaviour of the cells, and as they showed that there was much less sulphating with sodium sulphate, as shown by the specific gravity never falling to the same extent as in the plain cells, but that the general character of the changes in temperature and in specific gravity during charge and discharge were the same in both types of cell, and of the nature which the work of Prof. Ayrton and others has rendered familiar to all, it was only the distribution of temperature and of specific gravity which was investigated, and this was found to be very irregular.

It was found that the addition of sodium sulphate, in about the proportion of 1 per cent:, to freshly electrolysed acid, or during electrolysis, always produced a diminution in the total quantity of "active oxygen," and brought the amount present in the plain cells down almostly exactly to that found in the sodium sulphate cells.

Experiments on the growth of the "peroxides" were carried on during five charges and discharges, but only the figures relating to the first discharges are given, as the other charges and discharges are mere repetitions. The peroxides form at once, then undergo a diminution, and then increase again. The alteration in the totals is due mainly to actions occurring at the lead plate in the plain cell, as at the peroxide plate the amounts steadily increase ; in the sodium sulphate electrolyte there is a diminution at both plates, followed by an increase.

Determinations were made of the amounts of "active oxygen" present as persulphuric acid and hydrogen dioxide respectively, and it was established that acid taken from the cell reduced peroxide of lead. The presence of hydrogen dioxide being thus established, both directly and indirectly, its effect on the E.M.F. of a cell was tested. It was found that, while its addition to the acid in the case of a lead peroxide couple in dilute sulphuric acid produced an annulment or reversal of the E.M.F., the introduction of hydrogen dioxide into the body of the peroxide paste produced an increase of E.M.F. in the case of a platinum-lead peroxide couple. The latter experiment was made with a view of reproducing, if possible, the conditions of a cell which is started discharging directly it is fully charged, and in which the persulphuric acid formed at the positive during charge may be supposed to break up with the formation of hydrogen dioxide on the cessation of the charging current, thereby increasing the normal E.M.F. of the cell.

The cause of the pink colour of the acid noticed by Mr. Crompton and others was investigated, and found to be permanganic acid, formed probably from the manganese present in commercial lead.

In conclusion, the author points out :—

That "peroxides" are found in appreciable quantities in the electrolyte during charge and discharge ;

That their influence must not be neglected in considering the behaviour of the Planté cell ;

And that it is to the electrolyte rather than to the plates that attention must be directed if any considerable improvement is to be effected.

PART II.

A DISCUSSION OF THE CHEMICAL CHANGES OCCURRING IN THE CELL.*

BY H. E. ARMSTRONG, F.R.S., AND G. H. ROBERTSON.

The authors arrive in this Paper at the following conclusions :—

1. That the cooling observed in the Planté cell can only be explained as resulting from the dissociation of the dilute sulphuric acid ; and as the values given by Messrs. Ayrton, Lamb, Smith, and Woods are in practical agreement with those calculated on the assumption that the acid used is sulphuric acid itself, H_2SO_4, that in all probability such acid and not the dilute acid contained in the cell is operative throughout.

2. That the observed loss in efficiency cannot be due to temperature changes, as these arise through actions occurring out of circuit.

3. That it is difficult from a comparison of calculated with observed values of the E.M.F. to arrive at any final conclusion as to the exact nature of the changes which take place in the cell. On the assumption that sulphating occurs at both plates in circuit und under the influence of H_2SO_4, the calculated value is considerably too high ; while, if sulphating occur only at the lead plate, the value calculated is far too low.

4. That a counter E.M.F. of about 0·5 volt would account for the observed departure from the highest calculated value. As peroxides are always present in the electrolyte, it is conceivable that such a counter E.M.F. may exist ; moreover, there is also the possible influence of the lead support to be considered.

5. That the observed loss of efficiency is to be attributed to the formation of peroxides in the electrolyte, and to the excessive sulphating occurring chiefly at the peroxide plate in the local circuit existing between the support and the paste.

* Abstract of a Paper read before the Royal Society, June 11, 1891.

ON ELECTRICAL EVAPORATION.*

BY WILLIAM CROOKES, F.R.S.

It is well known that when a vacuum tube is furnished with internal platinum electrodes, the adjacent glass, especially near the negative pole, speedily becomes blackened, owing to the deposition of metallic platinum. Whilst a solid body like platinum requires an intense heat to enable its upper stratum of molecules, to pass beyond the sphere of attraction of the neighbouring molecules experiment shows that a very moderate amount of negative electrification superadds sufficient energy to enable the upper stratum of metallic molecules to fly beyond the attractive power of the rest of the metal. I have recently made some experiments upon the evaporation of different substances under the electric stress.

Evaporation of Water.—A delicate balance was taken, and two very shallow porcelain dishes were filled with acidulated water and balanced on the pans. Dipping into each dish—touching the liquid, but not the dish—was a platinum wire, one connected with the induction coil and the other insulated.

It was found that *negatively* electrified water lost in 1½ hours 1/1000th part of its weight more than did insulated water. This experiment shows that the disturbing influence which assists evaporation is peculiar to the negative pole, even at atmospheric pressures.

The metal cadmium was next experimented upon.

Evaporation of Cadmium.—If the flying-off of the metal of the negative pole is similar to evaporation or volatilisation the operation should be accelerated by heat.

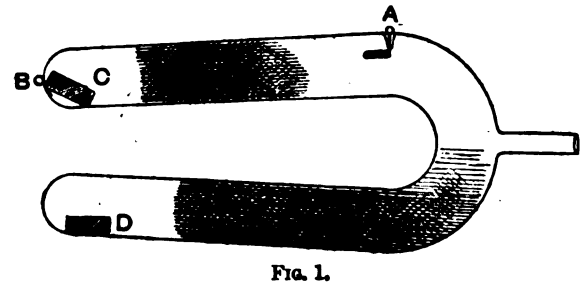

FIG. 1.

A tube was made as shown in Fig. 1. A and B are the platinum poles sealed through the glass. C and D are two blocks of metallic cadmium of the same size and weight. The piece C is in contact with the pole B, which in the experiment was always kept negative, the pole A being positive. When the exhaustion was such that the passage of the current gave green phosporescence over the glass, heat was applied simultaneously to both ends of the U-shaped tube by means of a gas-burner and air-bath, so that one piece of cadmium was at the same temperature as the other. The current was then applied and was kept on for about an hour, and it was remarkable that no metal was deposited in the neighbourhood of the positive pole, the surrounding portion of the tube being quite clean, while the corresponding part of the other limb of the tube, having no electrodes, was thickly coated, the appearance being shown in the drawing.

As the temperature was high, metal had distilled off from both

* Abstract of a Paper read before the Royal Society, June 11, 1891.

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lumps ; hence there was no visible difference in the amount of the deposit in the two sides. It is evident that, to render the electrical action most visible, the temperature should be kept short of the normal volatilising point.

In the next experiment an exactly similar tube was used ; the vacuum was such that the green phosphorescence of the glass was well seen, the temperature was kept just below the melting point of cadmium, and the current was kept on for an hour. On examining the tube at the end of this time, the appearance was as seen in Fig. 2. A considerable deposit had taken place on the end of the tube near the negative pole, the space round the positive pole was clear, while in the limb of the tube where no electricity had been passing only a very little deposit of metal was seen, as shown in the figure.

In these experiments no estimation was made of the weight of metal removed. To render the experiment quantitative, and at the same time to remove any disturbing effect that might be caused by heating at the point of indifferent contact, the following experiments were made :—

A U-shaped tube had a platinum pole sealed in each end. Six grains of pure cadmium were put into each limb and fused round the platinum wire. The ends of the tube were then put into an air-bath, and kept at a temperature of 200°C. during the continuance of the experiment. The exhaustion remained at 0·00076mm., or 1 M. The induction current was kept going for 35 minutes. At the end of this time it was seen that most of the cadmium had disappeared from the negative pole, leaving the platinum wire clean, no metal being deposited near it, and the molecules appearing to have been shot off to a distance of about $\frac{3}{4}$in. The appearance of the positive pole was very different ; scarcely any of the cadmium had been volatilised, and the condensed metal came almost close to the pole. The tube was opened, and the remaining wires and metal were weighed. The cadmium was then dissolved off the poles in dilute acid ; the residue was washed, dried, and weighed.

	Positive pole.	Negative pole.
Original weight of cadmium	6·00 grs.	6·00 grs.
Cadmium remaining on the pole	3·65 „	0·25 „
Cadmium volatilised in 35 mins.	2·35 „	5·75 „

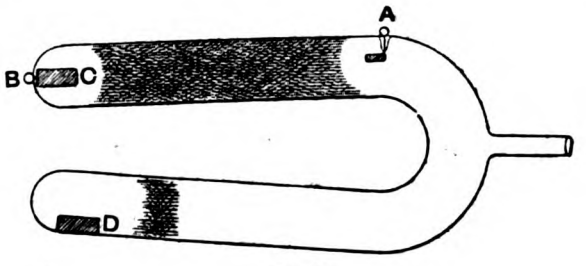

Fig. 2.

The difference between the amount of cadmium driven from the two poles having proved to be so decided, another experiment was tried in a tube so arranged that the metal could be more easily weighed before and after the experiment. In 30 minutes the experiment was stopped, and after all was cold the tube was opened and the wires weighed again. The results were as follows :—

	Positive pole.	Negative pole.
Original weight of cadmium	9·34grs.	9·38grs.
Weight after experiment.....	9·25 „	1·86 „
Cadmium volatilised in 30 min.....	0·09 „	7·52 „

Volatilisation of Silver.—Silver was the next metal experimented upon. Small lumps of pure silver were cast on the ends of platinum wires, and suspended to the inner ends of platinum terminals passing through the glass bulb. The platinum wires were protected by glass, so that only the silver balls were exposed. The whole apparatus was enclosed in a metal box lined with mica, and the temperature was kept as high as the glass would allow without softening. The apparatus was exhausted to a dark space of 3mm., and the current was kept on for 1½ hours. The weights of silver, before and after the experiment, were as follows :—

	Positive pole.	Negative pole.
Original weight of silver	18·14grs.	24·63grs.
Weight after the experiment	18·13 „	24·44 „
Silver volatilised in 1½ hours	0·01 „	0·19 „

It having been found that silver volatilised readily from the negative pole in a good vacuum, experiments were instituted to ascertain whether the molecules of metal shot off from the pole were instrumental in producing phosphorescence. A glass apparatus was made as shown in Fig. 3. A pear-shaped bulb of German glass has, near the small end, an inner concave negative pole, A, of pure silver, so mounted that its inverted image is thrown upon the opposite end of the tube. In front of the pole is a screen of mica, having a small hole in the centre, so that only a narrow pencil of rays from the silver pole can pass through, forming a bright spot of phosphorescence, D, at the far end of the bulb. The exhaustion was pushed to a high point, 0·00068mm., or 0.9 M. The current from an induction coil was allowed to pass continuously for some hours, the silver pole being kept negative, so as to drive off a certain portion of the silver electrode. On subsequent examination it was found that the silver had all been deposited in the immediate neighbourhood of the pole, whilst at the far end of the tube the spot D, that had been continuously glowing with phosphorescent light, was practically free from silver.

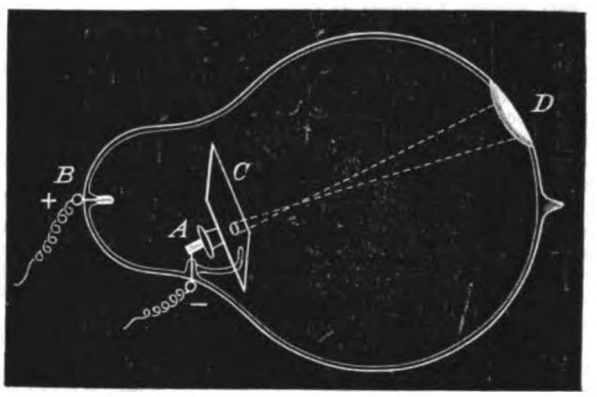

Fig. 3.
P=0·00068*mm.*
=0·9 M.

A tube was next made as shown in Fig. 4. It had two negative poles connected together, A, A′, so placed as to project two luminous spots on the phosphorescent glass of the tube. One of the electrodes, A′, was of silver, a volatile metal ; the other, A, was of aluminium, practically non-volatile. On connecting the two negative poles, A, A′, with one terminal of the coil, and the positive pole, B, with the other terminal, it was seen in the course of half-an-hour that a considerable quantity of metal had been projected from the silver negative pole, blackening the tube in its neighbourhood, while no projection of metallic particles took place from the aluminium positive pole. During the whole time of the experiment, however, the two patches of phosphorescent light, C and C′, had been glowing with exactly the same intensity, showing that the active agent in effecting phosphorescence was not the molecules of the solid projected from the poles, but the residual gaseous particles, or "radiant matter."

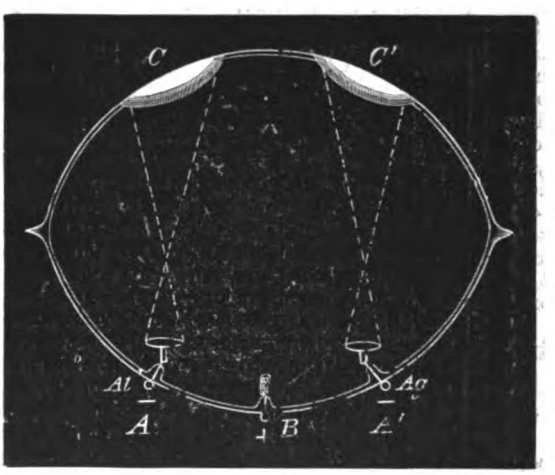

Fig. 4.
P=0·00068*mm*
=0·9 M.

If, for the negative electrode, instead of a pure metal such as cadmium or silver, an alloy was used, the different components might be shot off to different distances, and in this way make an electrical separation—a sort of fractional distillation. A negative terminal was formed of clean brass, and submitted to the electrical discharge *in vacuo* ; the deposit obtained was of the colour of brass.

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throughout, and on treating the deposit chemically I could detect no separation of its component metals, copper and zinc.

If we take several liquids of different boiling points, put them under the same pressure, and apply the same amount of heat to each, the quantity passing from the liquid to the gaseous state will differ widely in each case. It was interesting to try a parallel experiment with metals, to find their comparative volatility under the same conditions of temperature, pressure, and electrical influence. It was necessary to fix upon one metal as a standard of comparison, and for this purpose I selected gold, its electrical volatility being great, and it being easy to prepare in a pure state.

An apparatus was made with four negative poles at one end and one positive pole at the other. By a revolving commutator I was able to make electrical connection with each of the four negative poles in succession for exactly the same length of time (about six seconds); by this means the variations in the strength of the current, the experiment lasting some hours, affected each metal alike. The exposed surface of the various metals used as negative poles was kept uniform by taking them in the form of wires that had all been drawn through the same standard hole in the drawplate, and cutting them by gauge to a uniform length; the actual size used was 0·8mm. in diameter, and 20mm. long. The comparison metal, gold, had to be used in each experiment; the apparatus thus enabled me to compare three different metals each time. The length of time that the current was kept on the revolving commutator in each experiment was eight hours, making two hours of electrification for each of the four negative electrodes; the pressure was such as to give a dark space of 6mm.

The following table of the comparative volatilities was in this way obtained, taking gold as = 100:—

Palladium	108·00	Platinum	44·00
Gold	100·00	Copper	40·24
Silver	82·68	Cadmium	31·99
Lead	75·04	Nickel	10·99
Tin	56·96	Iridium	10·49
Brass	51·58	Iron	5·50

In this experiment equal surfaces of each metal were exposed to the current. By dividing the numbers so obtained by the specific gravity of the metal, the following order is found:—

Palladium	9·00	Cadmium	3·72
Silver	7·88	Copper	2·52
Tin	7·76	Platinum	2·02
Lead	6·61	Nickel	1·29
Gold	5·18	Iron	0·71
Iridium	0·47		

Aluminium and magnesium appear to be practically non-volatile under these circumstances. The order of metals in the table shows at once that the electrical volatility in the solid state does not correspond with the order of melting points, of atomic weights, or of any other well-known constant.

It is seen in the above table that the electrical volatility of silver is high, while that of cadmium is low. In the two earlier experiments, where cadmium and silver were taken, the cadmium negative electrode in 30 minutes lost 7·52 grs., whilst the silver negative electrode in 1½ hours only lost 0·19 gr. This apparent discrepancy is easily explained by the fact (already noted in the case of cadmium) that the maximum evaporation effect, due to electrical disturbance, takes place when the metal is at or near the point of liquefaction. If it were possible to form a negative pole *in vacuo* of molten silver, then the quantity volatilised in a given time would be probably much more than that of cadmium.

Gold having proved to be readily volatile under the electric current, an experiment was tried with a view to producing a larger quantity of the volatilised metal. A tube was made having at one end a negative pole cemposed of a weighed brush of fine wires of pure gold, and an aluminium pole at the other end. The tube was exhausted and the current from the induction coil put on, making the gold brush negative; the resistance of the tube was found to increase considerably as the walls became coated with metal, so much so that, to enable the current to pass through, air had to be let in after a while, depressing the gauge ½mm. The weight of the brush before experiment was 35·4949 grs. The induction current was kept on the tube for 14½ hours; at the end of this time the tube was opened and the brush removed. It now weighed 32·5613, showing a loss of 2·9327 grs. When heated below redness the deposited film of gold was easily removed from the walls of the tube in the form of very brilliant foil. After having been subjected to electrical volatilisation, the appearance of the residual piece of gold under the microscope, using a ¼in. object glass, was very like that of electrolytically deposited metal, pitted all over with minute hollows.

This experiment on the volatilisation of gold having produced good coherent films of that metal, a similar experiment was tried, using a brush of platinum as a negative electrode. On referring to the table it will be seen that the electrical volatility of platinum is much lower than that of gold, but it was thought that by taking longer time a sufficient quantity might be volatilised to enable it to be removed from the tube. The vacuum tube was exhausted to such a point as to give a dark space of 6mm., and it was found, as in the case of gold, that as a coating of metal was deposited upon the glass the resistance rapidly increased, but in a much more marked degree, the residual gas in the tube apparently becoming absorbed as the deposition proceeded. It was necessary to let a little air into the tube about every 30 minutes, to reduce the vacuum. This appears to show that the platinum was being deposited in a porous spongy form, with great power of occluding the residual gas. Heating the tube when it had become in this way non-conducting liberated sufficient gas to depress the gauge of the pump 1mm., and to reduce the vacuum so as to give a dark space of about 3mm. This gas was not re-absorbed on cooling, but on passing the current for ten minutes the tube again refused to conduct, owing to absorption. The tube was again heated, with another liberation of gas, but much less than before, and this time the whole was re-absorbed on cooling. The current was kept on this tube for 25 hours; it was then opened, but I could not remove the deposited metal except in small pieces, as it was brittle and porous. Weighing the brush that had formed the negative pole gave the following results:—

	Grains.
Weight of platinum before experiment	10·1940
,, after experiment	8·1570
Loss by volatilisation in 25 hours	2·0370

Another experiment was made similar to that with gold and platinum, but using silver as the negative pole, the pure metal being formed into a brush of fine wires. Less gas was occluded during the progress of this experiment than in the case of platinum. The silver behaved the same as gold, the metal deposited freely, and the vacuum was easily kept at a dark space of 6mm. by the very occasional admission of a trace of air. In 20 hours nearly 3 grs. of silver were volatilised. The deposit of silver was detached without difficulty from the glass in the form of brilliant foil.

PHYSICAL SOCIETY.

At the meeting of the Physical Society, on Friday last, Prof. AYRTON read a Paper by himself and Dr. Sumpner,

"On Alternate Current and Potential Difference Analogies in the Methods of Measuring Power."

In a Paper read before the Society in March last, the authors pointed out that for every method of measuring power in which readings of volts and amperes were taken, other methods in which amperes were read instead of volts, and volts instead of amperes, could be devised. More recently, Dr. Fleming had, by a transformation of a formula given by the authors in a communication made to the Royal Society on the measurement of power by three voltmeters, given the analogue in which three ammeters were employed. The two arrangements are represented in Figs. 1 and 2,

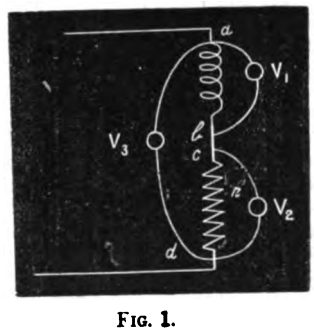

FIG. 1.

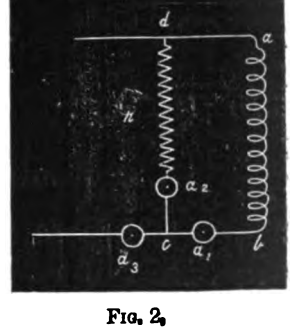

FIG. 2.

whilst Fig. 3 shows a modification of Dr. Fleming's method (Fig. 2), in which the current in the non-inductive resistance r is measured by the aid of a voltmeter, V, across its terminals. This obviates the necessity of putting an electro-magnetic instrument in what should be a non-inductive circuit. The formula for the mean watts spent in the circuit $a\ b$, Figs. 1 and 2, are respectively

$$W = \frac{1}{2}\frac{1}{r}(V_3^2 - V^2 - V_2^2) \text{ and } W = \frac{r}{2}(A_3^2 \quad A_1^2 = A_2^2)$$

Mr. Blakesley's method of measuring power by a split dynamometer was shown to be analogous to the original electrometer method, in which the difference of the two readings was proportional to the power, and Blondlot and Currie s double electrometer

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method was shown to be the analogue of the ordinary wattmeter. The wattmeter was defective in the fact that a solenoidal coil was inserted in a nominally non-inductive circuit. The error thus introduced is, as was shown by one of the authors some years ago, expressed by the formula—

$$\frac{\text{Apparent watts}}{\text{True watts}} = \frac{1+\tan\theta\tan\phi}{1+\tan^2\phi}$$

where θ is the phase angle between the current and E.M.F. in the circuit in which the power is to be measured, and ϕ the phase angle for the approximately non-inductive circuit. It is now proved that the same formula expresses the error in any of the methods where resistances not wholly non-inductive are used.

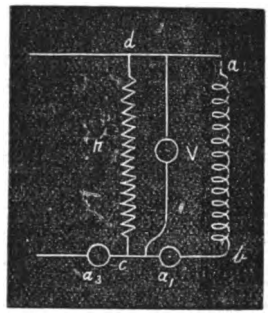

FIG. 3.

As is well-known, Mr. Blakesley has applied his split-dynamometer to the measurement of phase differences between two currents; and an analogous method of finding the phase difference between two potential differences is described in the Paper. In this method a high resistance split-dynamometer, such as suggested by Mr. Rimington for measuring power, is employed. Blondlot and Currie's double electrometer could also be used for the same purpose. Numerous diagrams illustrating the various analogies accompany the Paper.

DISCUSSION.

Prof. S. P. THOMPSON enquired whether hot-wire voltmeters could be employed to measure the various potential differences, without introducing error?

In reply, Prof. AYRTON said that the error introduced by the self-induction of these instruments was generally negligible, yet the fact that they required considerable current was a disadvantage, and as these currents were not always in the same phase as those in other circuits, troublesome corrections were sometimes necessary. Electrostatic instruments were preferable.

Prof. ADAMS said he was glad to hear that the inductance of Cardew voltmeters introduced no serious error, for they were very convenient instruments to use.

Dr. Oliver Lodge exhibited and described two forms of clocks for pointing out the direction of the motion of the earth through space.

Some experiments with Leyden jars were then shown by Dr. Lodge. The first one was with resonant jars, in which the discharge of one jar precipitated the overflow of another, when the lengths of the jar circuits were properly adjusted or tuned. The latter jar was entirely disconnected from the former, and was influenced merely by electro-magnetic waves emanating from the discharging circuit. Lengthening or shortening either circuit prevented the overflow. Correct tuning was, he said, of great importance in these experiments, for only a dozen or more oscillations occurred before the discharge ceased. The effect could be shown over considerable distances. In connection with this subject Mr. Blakesley had called his attention to an observation made by Priestly many years ago, who noticed that when several jars were being charged from the same prime conductor, if one of them discharged, the others would sometimes also discharge, although they were not fully charged. This, he, Dr. Lodge, thought might be due to the same kind of influence which he had just shown to exist. The word *resonance*, he said, was often misunderstood by supposing it always had reference to sound, and as substitutes he thought that the words *syntonic* or *syntony* might be allowed.

The next experiment was to show that wires might be tuned to respond to the oscillation of a jar discharge, just as a string could be tuned to respond to a tuning fork. A thin stretched wire about 50 or 60 feet long, suspended in the room, was connected to the knob of a jar and another parallel one to its outer coating, and, by varying the length of an independent discharging circuit, a glow was caused to appear near the remote halves of the stretched wires, at each discharge. Each of the wires thus acted like a stopped organ pipe, the remote ends, which were insulated, being the nodes at which the variations of pressure are greatest. By using long wires he had observed a glow on portions of them with the intermediate parts dark; this corresponded with the first harmonic, and, by measuring the distance between two nodes, he had determined the wave length of the oscillations. The length so found did not agree very closely with the calculated length, and the discrepancy he thought due to the specific inductive capacity of the glass not being the same for such rapidly alternating pressures as for steady ones. He also showed that the electric pulses passing along a wire could be caused (by tuning) to react on the jar to which it was connected, and cause it to overflow even when the distance from the outside to the inside coating was about 8in. During this experiment he pointed out that the noise of the spark was greatly reduced by increasing the length of the discharging circuit. The same fact was also illustrated by causing two jars to discharge into each other, spark gaps being put both between their inner and outer coatings, so as to obtain "A" sparks and "B" sparks. By putting on a long "alternative path" as a shunt to the B spark gap, and increasing that gap, the noise of the A spark was greatly reduced. He had reason to believe that the B spark was a quarter phase behind the A spark, but the experimental proof had not been completed.

He next described some experiments on the screening of electromagnetic radiation, in which a Hertz resonator was surrounded by different materials. He had found no trace of opacity in insulators, but the thinnest film of metal procurable completely screened the resonator; cardboard rubbed with plumbago also acted like a nearly perfect screen. In connection with resonators, he exhibited what he called a *graduated electric eye* or an electric harp (Fig. 4),

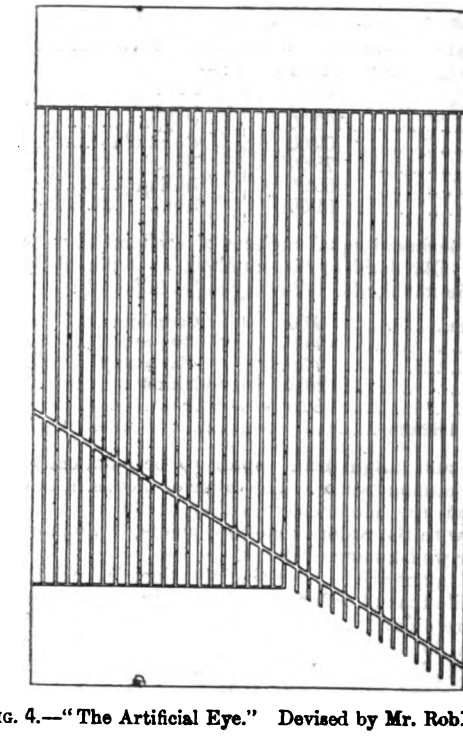

FIG. 4.—"The Artificial Eye." Devised by Mr. Robinson.

devised by his assistant, Mr. Robinson, in which strips of tinfoil of different lengths are attached to a glass plate, and have spark gaps at each end, which separate them from other pieces of foil. One or other of the strips would respond according to the frequency of the electro-magnetic radiation falling upon it.

DISCUSSION.

Mr. BLAKESLEY asked whether the tuning of the resonant jars needed readjustment when the distance between their circuits was varied, for, according to theory, the mutual induction should diminish the self-induction of the primary, and cause its oscillations to be more rapid. If this was true, the method might be used for getting rapid oscillations. He also inquired whether the glow would appear in the same position on the two stretched wires if their ends were joined?

Dr. SUMPNER wished to know how the resistances, inductances, and capacities of the circuits and jars were determined, and whether any evidence of irregular distribution of the charges on the tinfoil had been noted, since such irregularity might account for the apparent change in the capacity. With reference to the overflowing of a jar caused by connecting up a certain length of wire in the discharging circuit, he asked whether the overflow did not prove the existence of a higher potential than that which originally existed between the coatings of the jar, and, if so, where did the excess energy come from?

Dr. THOMPSON asked if it would be possible to make a wire circuit analogous to an open organ pipe by putting sheets of metal on the ends of the wires?

Dr. LODGE, in reply, said Mr. Blakesley's suggestion was an important one, but he had not observed that any change in the adjustment was necessitated by varying the distance between the resonating circuits. Neither

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had he noticed any glow on wires joined to form a single loop, but this might be possible if the wires were long enough to give harmonies.

In answer to Dr. Sumpner, he said that the capacities were difficult to determine, for with such rapid oscillations the coatings were virtually enlarged. Lord Rayleigh had shown how to calculate the inductances, and the resistances he had practically measured by his alternative path experiments. The overflow of jars, he thought, was caused by the charges in some way concentrating on the edges of the foil, thus causing a kind of flood tide at which the overflow occurred.

The PRESIDENT asked Dr. Lodge what his views were as to the cause of the opacity of ebonite to light. Was it due to a selective absorption which cut off only the rays to which the eye was sensitive, or was the ordinary explanation, that it contained impurities which were conducting, and hence acted as screens, likely to be correct? Another possible explanation was that the motion of the ether particles may be in three dimensions, and light be due to the projection of this motion on a plane perpendicular to the ray, whilst electro-magnetic induction might be due to the other component.

Dr. LODGE said he believed that ebonite was not opaque, because of conducting particles being present, and was inclined to think that it acted more like ground glass, in which the opacity was due to internal reflections. Such a substance would only be opaque to vibrations whose wavelength were comparable with the size of the particles.

LEGAL INTELLIGENCE.

Allison v. City and South London Railway.

In the Chancery Division on Tuesday and Wednesday the case of Allison v. City and South London Railway Company came before Mr. Justice Kekewich. This was an action brought by the Trustees of the Stockwell Orphanage, Clapham-road, against the City and South London Railway Company for damages, and an injunction to restrain the Company from working three engines of 400 H.P. which were used for driving the dynamos for the purpose of working the electric railway. The plaintiffs' case was that the vibration and noise caused by the engines, together with the condensed steam, created such a nuisance as no statutory powers conferred on the Company could possibly cover. The plaintiffs further contended that if certain appliances had been used by the Company the nuisances might have been, if not absolutely abated, greatly mitigated. The defendant Company denied negligence in the use of their engines, and contended that in all they had done they had acted under statutory powers.

Mr. Rigby, Q.C., Mr. Renshaw, Q.C., and Mr. Ingle Joyce appeared for the plaintiffs; while Mr. Cozens-Hardy, Q.C., Mr. W. Graham, and Mr. Gwynne James represented the defendant Company.

Mr. HENRY LEE, consulting engineer, of 28 years' experience, gave evidence in support of the plaintiffs' case. He said that three of the houses at the Orphanage were uninhabitable for ordinary purposes, owing to the noise and vibration caused by the engines at the defendant Company's generating station. Clouds of steam also came from the exhaust pipe, and were a great nuisance.

In cross-examination, witne s said he had not had any actual experience of electrical railways. If felt were used to put an end to the noise the vibration would remain, so as to make the houses uninhabitable. In re-examination, witness said with the present engines there would be a difficulty in reducing the vibration so that it would not be a nuisance to the adjoining premises. If different engines and different beds were used on the same site, he thought that there would be a risk of vibration. The nuisance might be abated by changing the position of the generating station and using different engines.

By the JUDGE: The vibration extended over a circular area of from 100 to 150ft.

Mrs. STIFF, the wife of one of the plaintiffs, said she had been in the habit of holding a Bible class in one of the rooms of the first house of the Orphanage. The Company commenced to run trains on Sundays in April last. The vibration felt in the room in which she held her Bible class was very disagreeable, and had a serious effect upon the members of her class. She had to abandon the room, and hold her class in the fourth house. Her private residence adjoined the railway, and had suffered from the vibration and the steam and grease which came from the exhaust pipe.

In cross-examination, the witness said her husband opposed the Bill authorising the construction of the railway when it was before Parliament, and incurred expense. Her husband had offered to sell his garden to the Company because of the nuisance of the railway.

Other evidence having been given, the case for the plaintiffs closed.

Sir B. BAKER was then called on behalf of the defendant Company. He said he had been consulting engineer to the Company ever since it was started. The works in question were erected under the immediate control of Mr. Greathead, the engineer to the Company. Mr. Greathead consulted witness and Sir J. Fowler with regard to the generating station. The engines and dynamos at the station were well constructed, and suited for the work they were intended to perform. The engines were of the most approved type. He did not agree that it would be a great improvement if the engines were not connected with the dynamos by long straps, but were worked directly in connection with the dynamos. The question of the adoption of the engine suggested by Mr. Lee was considered, and it was resolved not to have it. The beds of the engines were constructed and carried out with all due care.

In cross-examination, witness said the generating station was covered with thin plates of corrugated iron. He did not think that was the best kind of roof for keeping out the noise caused by the working of the machinery, though he would not say it was the worst. By making certain alterations in the roof it would be possible to reduce the noise.

Mr. GREATHEAD, engineer to the Company, stated that it was necessary for the defendant Company to increase their shed accommodation, because they were adding to their rolling stock to meet the traffic on the line. The engine house was designed by him, and the engines used were of the most approved type. He had visited the Orphanage, but had not noticed such noise or vibration as could be described as a nuisance to the inmates.

In cross-examination, witness said the corrugated roof of the generating station was not the best that could be devised for keeping out the noise of the engines and machinery. In consequence of the complaints at the Orphanage he went there and made an examination. He noticed some noise and vibration, and he had no doubt that they proceeded from the defendant Company's engines. On the occasion of his last visit to the Orphanage there was no substantial vibration or noise. He did not admit that any time the noise and vibration produced by the machinery caused the inmates of the Orphanage any annoyance.

Mr. BASIL MOTT, resident engineer in charge of the defendant Company's works, gave corroborative evidence.

The further hearing of the case was adjourned till Thursday.

THURSDAY, JUNE 18TH.

Mr. GEO. HOPKINS, civil engineer, stated that he visited the generating station on Friday, the 5th inst., and that he subsequently went to the Orphanage, where he detected a slight noise and vibration when the engines were at work. He believed that the noise proceeded from the open roof, doors, and windows of the engine station, and therefore he should advise the Company to try some felt. The vibration was caused by the action of the engines. To lessen the noise and vibration he should advise the Company to do away with the openings in the roof of the generating station, and to fill up certain openings in a wall near the boundary line. In cross-examination, witness admitted that he would not like to live in the first house at the Orphanage. He should object to the noise, but not to the vibration.

By his LORDSHIP: He would not like to bring up his children in the first house of the Orphanage.

Witness, in re-examination, said the defendant Company's engines were well constructed and properly worked. When he went to the Orphanage he was convinced in his own mind that he should detect both noise and vibration.

At the conclusion of the witness's evidence,

His LORDSHIP said the questions he had to try were whether there was any nuisance independently of the Parliamentary power of the defendant Company, and whether, assuming there was a nuisance, it could not be abated. The answer to the second question might depend, to some extent, on the further question, whether the Company had done all that they possibly could to prevent the nuisance. The Company's Parliamentary powers were a good defence if they satisfied the Court that they had done their very best to stop the noise and vibration. After the evidence of Mr. Hopkins it seemed to him impossible to say that the Company had done their very best, because that gentleman had suggested several possible improvements He, therefore, put it to the Company whether it would not be desirable for them to take a reasonable time to see what they could do to abate what he (the learned judge) regarded as an existing nuisance before they approached the moot point of law as to their Parliamentary powers.

Mr. COZENS HARDY said the Company were quite prepared to try felt.

His LORDSHIP remarked that Mr. Hopkins had said something might be done to abate the nuisance as regarded the noise and vibration. That gentleman was clearly of opinion that there was a great noise, going far to render the house uninhabitable. If, after the defendant Company had done their best the nuisance still remained, the question as to the Company's Parliamentary powers would arise.

Mr. COZENS HARDY said he would concede to his Lordship's suggestion. The case would, therefore, stand adjourned.

Mr. RENSHAW hoped that there would be no delay.

His LORDSHIP said the case must be disposed of between now and the 12th of August.

Mr. COZENS HARDY said if the plaintiffs had any suggestion to make the defendant Company would consider it.

Mr. RENSHAW thought that the best course would be for the defendant Company to draw up some scheme and submit it to the plaintiffs.

The case was accordingly adjourned *sine die*, with liberty to either party to apply to have it put into the list.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *June* 5, 1891.

The Edison Incandescent Lamp Patent.—The matter of greatest interest now before the electrical public is the trial, just completed, of an action involving the validity of the Edison Incandescent Lamp patent. The incandescent lamp has been the subject of serious litigation in this country but once previously, namely, in the action of the Consolidated Electric Light Company (Sawyer-Man patent) *v.* the McKeesport Light Company, using the Edison lamps. Decision in this case was reached October 5th, 1889, and its result was the demolition of the Sawyer-Man claims. During the progress of this suit the Edison Company opened the counter suit that has just been tried. The preliminary steps had been

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taken several years before the date mentioned, but, owing to interferences in the Patent Office and other legal complications, nothing serious was done until about the time of the McKeesport decision. Justice Bradley's opinion in this case was remarkable in that it upset the Sawyer-Man patent, and, while nominally sustaining the Edison claims, damaged them rather seriously in its decision as to the state of the art. Now the incandescent lamp question is coming to a legal decision in rather definite form. The claim on which the matter hinges is the second one of Edison's patent, the same thing that has been sustained in the English courts, to wit: the combination of carbon filament with a receiver made entirely of glass, and conductors passing through the glass, and from which receiver the air is exhausted for the purposes set forth. The attack of the Edison Company is along the line pursued in the English litigation, on the question of the great influence of Edison on the art, and his production of a high resistance carbon lamp at a time when his competitors were working with comparatively low resistance lamps. The defence is, as it has been in previous cases, lack of invention and lack of novelty in the Edison patent, considering the previous state of the art. It is undoubtedly true that the claim of the Edison Company that a high resistance carbon lamp was the first practical commercial lamp, and that Edison introduced this lamp is pretty well substantiated, but the truth to tell, the patent in the suit doesn't cover the case nearly as well as it might. Edison was in the Patent Office for several years with an application of somewhat broader character, which he was not successful in obtaining, therefore this action for infringement had to be brought on the original patent, of which the second claim is the only valuable part. The arguments of counsel for Mr. Edison were intended, in the first place, to show the insufficiency of previous lamps to meet the commercial requirements of the case; second, the importance of the modifications introduced by Mr. Edison; third, the consequent developments of the commercial incandescent lamp. The counsel for the Westinghouse Company (the real defendant in this case) have endeavoured to show, in the first place, that the use of carbon in incandescent lamps is old; that the use of an exhausted receiver is old; that the use of platinum leading wires sealed through glass and an incandescing conductor of considerable resistance had been anticipated at the time the application for this Edison patent was filed. The first point is easily shown. The exhausted receiver had been shown pretty completely both by King and in the Adams lamp, which, unfortunately for the defendant, had not been published or patented. The high resistance claim had been to a certain extent anticipated by the platinum lamp of Mr. Edison himself, and the suggestions of Lane-Fox. While it is undoubtedly true that Edison was the pioneer of carbon high-resistance lamps, and that subsequent inventions immediately copied this peculiar arrangement, it is contended on the other hand that the present suit is only brought after nearly a decade has elapsed and the contestant had failed to secure broad claims. Further, that no attempt was made to enforce the patent until a vast amount of capital had been enlisted in the manufacture of lamps by various parties, and the stakes were, therefore, enormously great. A peculiar feature of the case is the fact that the very experts who endeavoured to show the virtue of the invention in the Sawyer-Man case during the McKeesport trial, are now engaged in denying similar virtues to the Edison lamp of the same period. The complainant undoubtedly depends very greatly on the effect of Edison's name, and the general results of his work, rather than on a close interpretation of the specific claims of the patent. The defendant attacks the particular patent in suit, and also raises the claim that much of the commercial success of the incandescent lamp so strongly urged by the Edison Company was due to the system of distribution, and the production of a successful dynamo. By a curious coincidence, too, the experts who in the present case lay great stress on the importance of the lamp as a factor in commercial success, have been employed in the Edison feeder patent, and there take the position that the lamp was only a convenient concomitant of the very valuable and supremely important matter of the system of distribution. In fact, some of the experts on both sides have made a showing that is anything but creditable, and they have, in consequence, been severely scorched by the counsel. The decision will not probably be rendered before the end of the current month, and in all probability the case will be appealed to the newly constituted circuit court of appeals for final decision. The counsel for complainant appear firmly to believe that the second claim will be given a construction broad enough to cover the modern incandescent lamp, while the defendant expects that the patent will be sustained, but with such limitations as to make it practically useless. To sum the matter up, in spite of the great influence of Edison's work on the incandescent lamp, he is suing on a patent that looks somewhat shaky, in spite of its having been sustained in some foreign decisions, and the opinion in the McKeesport case, while generally upholding the Edison claims, injured them incidentally.

The Rapid Transit Question in New York.—The decision of the rapid transit commissioners has been received by the public with somewhat qualified assent. The Gould interests of this city are, of course, very strong, and there is a decided tendency to favour some extensions of the elevated railroad system, probably for the reason that a considerable addition could be made to these lines in less time than it would take the engineers of the tunnel system to get fairly settled down to their work. Nevertheless, there is little likelihood that the elevated roads will receive the commission they ask for to seize upon Broadway for an express service. A tunnel we are likely to have; and, given this, electric motive power follows as a matter of course. Incidentally, it may be mentioned that the Hudson River tunnel, now nearing completion, will probably be equipped with electric motors, and proposals have already been received from the Thomson-Houston Company for furnishing electric locomotives adequate to handle heavy trains at the highest speed desirable under the circumstances.

TRADE NOTES AND NOTICES.

This day "The Electrician" Company will publish "The Electrician" Primers (38 in all) in two volumes, price per volume 2s. paper covers, 2s. 6d. cloth; post free, 2s. 2d. and 2s. 9d. respectively. Single copies, 3d.; post free, 3½d. Prospectus on application to the Publisher.

Tenders Invited.—The Corporation of Dover invite tenders for the execution and maintenance of works needed for the supply of electricity within the borough. Copies of the conditions may be obtained of Mr. E. Wollaston Knocker, town clerk, to whom tenders must be delivered not later than Friday, July 10th. Further particulars appear in our advertisement columns.

——— The Taunton Town Council invite tenders for the supply and erection of electrical fire calls. All information may be obtained at the office of the Water Works Manager, Municipal buildings, Taunton, and tenders must reach Mr. T. Meyler, town clerk, by July 6th.

Sales by Auction.—Our advertisement columns contain announcements of the sale by auction, by Messrs. Hobson, Richards and Co. (by order of Mr. Justice Kekewich) of the plant, stock and machinery of the Electrical Engineering Corporation (Limited), at the Alliance Engineering Works, West Drayton, and No. 36, Albert Embankment. The sale at the Alliance Works is on Tuesday, June 30th, and following days, and at No. 36, Albert Embankment, on Tuesday, July 14th, and following days.

Oriental Telephone Company (Limited).—An official notification appears in our advertisement columns that a petition has been presented to the Chancery Division of the High Court of Justice for confirming a special resolution authorising certain alterations in the Company's Memorandum of Association. This petition is to be heard before Mr. Justice North, on Saturday, July 11th, when any creditor or shareholder of the Company desirous of opposing the making of an Order in compliance with the petition must attend by himself or counsel.

Appointment.—Mr. A. H. Hardie Trott has accepted the position of electrical engineer to the British Guiana Electric Lighting and Power Company (Limited).

Messrs. Barnett, Wynne and Barnard.—We regret to learn that the electrical department of this firm was totally destroyed by

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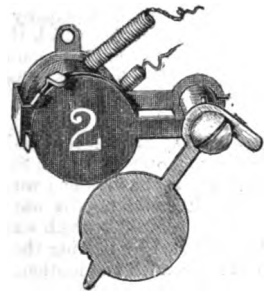
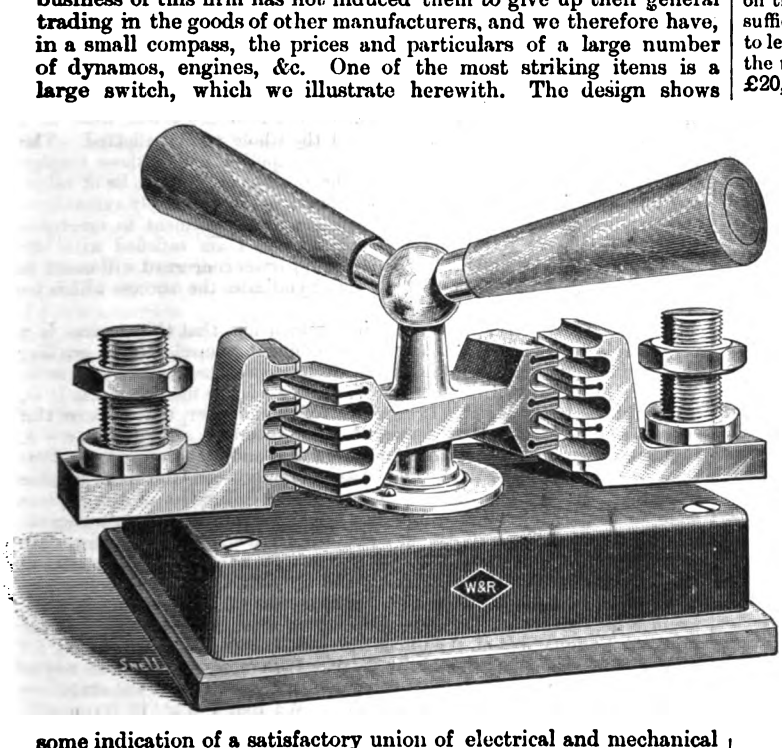
the fire which occurred at Newcastle-on-Tyne on Saturday last. All the drawings and testing instruments were lost, and the firm are suffering great inconvenience in consequence.

MR. H. THORPE.—Mr. Thorpe sends us particulars of his improved design of patent semaphore indicator, and we give a small illustration of the indicator. It has been in use for five years, and the inventor has put down new and special tools for the newly designed patent. It is claimed for the indicator as a



special advantage that when the disc is dropped there is a full white opening to show clearly and regularly which action is being used. In the printed particulars issued by Mr. Thorpe a flattering testimonial is set out from Prof. Silvanus P. Thompson in his Cantor Lecture delivered in the early part of 1890.

WOODHOUSE AND RAWSON'S CATALOGUE.—Whatever degree of finality may have been reached in the design and construction of dynamos, batteries, switches, and the innumerable goods which are known as contractors' supplies, the last new catalogue shows that the art of collating price lists knows no such limit, and the six sections which we have received of the present example excel anything of the kind that has yet been put forward. The whole catalogue will consist of eight parts, dealing with (1) boilers, engines, turbines, &c.; (2) dynamos, motors, and accumulators; (3) arc and incandescent lamps; (4) switches, switchboards, &c.; (5) fittings and shades; (6) instruments; (7) machine tools, sundries, &c. The fifth section has been surpassed, as might be expected, by some of the artistic efforts of our decorative metal workers, but, as a whole, the catalogue is particularly useful since the extended manufacturing business of this firm has not induced them to give up their general trading in the goods of other manufacturers, and we therefore have, in a small compass, the prices and particulars of a large number of dynamos, engines, &c. One of the most striking items is a large switch, which we illustrate herewith. The design shows



some indication of a satisfactory union of electrical and mechanical engineering. The independent stiff spring faces are good, since the strain on one pair need not affect the seating of the others. The small radius of the contacts and the large radius of the handles is also noteworthy. The description in the catalogue speaks of the distribution of sparking over a large number of points, but in our opinion matters should almost always be so arranged that a large current should never be broken, or, indeed, made by means of a switch. The only thing that we do not like about this pattern is the split terminals. These are good enough for temporary work, but, as we have before observed, the only workmanlike way of connecting a cable is by thimbles sweated on the end. These, we observe, are provided on the double pole two-way switch on p. 186 of the catalogue.

SANITAS COMPANY (LIMITED).—This Company, who are the manufacturers of the well known "Sanitas" specialities, have recently brought out the "Sanitas Disinfector." This should be found useful in large establishments where numbers of workmen are employed, particularly while the influenza epidemic is prevalent.

COMPANIES' MEETINGS & REPORTS.

City and South London Railway Company (Limited).

An extraordinary general meeting of this Company was held on Tuesday, at Winchester House, Old Broad-street, for the purpose of considering special resolutions for increasing the capital of the Company. Mr. C. G. Mott presided.

The CHAIRMAN explained that the shareholders would remember that the question of additional sidings at Stockwell was approved by them at the last meeting, and the question of further engine power and rolling stock was referred to in the last report; and what they had to decide upon now was the most economical method for increasing the capital for such payment. The amount they proposed to raise was about £50,000. As to the working of the concern he considered it had been most satisfactory, for all the arrangements at first had to do with the new power—electricity, for which they could not get a trained staff, but had had to educate a staff for the purpose. The men, however, had now become more efficient, and they were able to reduce the number of the staff. Another point was that the electrical engines supplied to them had not done the amount of work anticipated by the Directors. The locomotives had not been up to the power which they had expected, and they had accordingly ordered further locomotives from other makers, which they trusted would enable them to run their trains more frequently and at a greater speed. They had carried during the time that the line had been opened three millions of people in perfect safety. The question of how the additional money was to be raised had received their most careful consideration, and they had arrived at the conclusion that an issue of preference shares would probably be the best course at the present time. As to the results of the operations of the Company, he thought that under the circumstances of their being an entirely new line, they must be regarded as perfectly satisfactory. They were earning at the present moment an income at the rate of £40,000 per annum, and the whole of the working expenses, including administration charges, were estimated as near as they could get them at £28,000, which left a profit of £12,000 per annum on their present earnings. This, of course, was very small, but it was sufficient to pay their debenture interest, which was a little over £8,000, and to leave a margin of between £3,000 and £4,000 over. He hoped that during the next 12 months they would increase their receipts by from £10,000 to £20,000, and perhaps reduce their expenditure, and then they would be able to pay a moderate dividend upon the ordinary share capital of the Company. Altogether he thought the working of a new system such as theirs with such results must be regarded as satisfactory, and he concluded by moving the following resolution, explaining that the shareholders, having previously authorised the issue of ordinary new capital, must first cancel that power before they could issue preference capital:—

"*That the resolution passed at the general meeting of the Company held on August* 12, 1890, *relating to the creation of the new capital authorised by the City and South London Railway Act*, 1890, *be and the same is hereby cancelled and annulled except as to the creation and issue of* 5,000 *ordinary shares of* £10 *each, part of the total number of* 20,000 *shares authorised by the same resolution.*"

Mr. HANBURY seconded the resolution.

Mr. COURT, as representing a large number of ordinary shares, objected to the raising of preference capital, and moved an amendment for the adjournment of the meeting for 14 days for the further consideration of the matter.

Mr. MIDDLETON seconded the amendment.

Mr. PETO supported the original proposal, and expressed his satisfaction at the results already achieved by the Directors in regard to the working of the Company.

After some further discussion the CHAIRMAN expressed his willingness to accept the amendment, and it was accordingly put to the meeting and carried.

The proceedings then terminated.

Electric and General Investment Company (Limited).

The second ordinary general meeting of the shareholders of this Company was held, on Wednesday last, at Winchester House, Old Broad-street, under the presidency of the Duke of Marlborough.

The SECRETARY (Mr. J. Cecil Bull) read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN said he had great pleasure in bringing before the notice of the shareholders the report which had been drawn up for their perusal, and at the same time he thought it would be a proper time to make a few supplementary remarks on the subject. In the first place,

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they would see that the net profit which had been earned by the Company to May 31st was £2,592. 6s., which was to be distributed in the form of a 10 per cent. dividend, together with a bonus of 12s. 6d. per cent. on the capital paid up on the ordinary shares. It was also proposed to place £265. 10s. 9d. to reserve, to pay a dividend of £1. 5s. on each founder's share, to pay £59. 4s. 6d. additional remuneration to the Directors in accordance with the Articles of Association, and to carry forward £16. 10s. 9d. in equal moieties on account of the ordinary and founders' shares. Generally speaking, of course, this was a very poor year in the nature of things in point of business. It was the first year in which they had embarked in their enterprise, and he thought a great deal of credit was due to the persons who had taken the prime interest in its formation. The establishment of the Company was attributable to two or three gentlemen who foresaw the enormous development that was likely to take place in the electric lighting industry, which, to a large extent, had been up to the present in its infancy. The moment, however, had now come when electric lighting had reached a commercial basis. During the last 10 years it had been in a state of tentative progress—marred by many failures. But those failures had taught people the lines on which to proceed, not only with regard to improving the appliances for electric lighting, but as to the way of dealing with them commercially. Engineers were now able to give exact figures as to the cost of producing power sufficient to light a given number of lights. Given a certain area, they knew the estimates that might be made for lighting it, and they could also calculate with very great certainty the profit that would be derived from such an undertaking. They would, therefore, understand that that point having been arrived at, it was quite natural that they should look upon the question of electric lighting as having reached what he would call a commercial basis. The gentlemen who proposed to the shareholders to invest their money in this undertaking foresaw that large demands would be made for capital for carrying out various projects for lighting both the City of London and provincial towns. He might say that from the year's experience they had gained of the condition of the industry they saw promise of enormous business in all directions. Not only were private individuals engaged in forming companies for lighting towns, but municipalities were also embarking on the same enterprise; and, as they were aware, Provisional Orders had been applied for for districts and towns all over England. Those Provisional Orders would lead to the formation of companies which would have to be financed. The function of this Company was to set those enterprises on their legs, and to set them on their legs on a thoroughly conservative basis—in other words, to select those that promised well, and to reject others, which, as far as they could determine from experience, they did not think were suitable for pushing. As far as he had been able to judge from what had been brought before the Board there was great promise of development in the future. Of course the absolute business which they had done this year had not been very large, though, having regard to the amount of subscribed capital, he thought the results would be regarded as satisfactory. He hoped that in another year they would see a large increase of business. He could hardly take them into the confidence of the Board so far as the proposals before them were concerned; but there were many subjects of very great importance which they had to consider, and, of course, they must remember that the condition of the money market had not been very favourable for them. In fact it was necessary for any such company as this to proceed with very great caution. Some years ago one had only to bring out any company on the London market, and there was no difficulty in finding subscribers. He thought, however, that the present period of depression would gradually pass off; and, whatever might be said of the want of success which had attended some foreign ventures in the last few years, a good home industry would be likely to produce satisfactory results. They knew what railways and gas and water companies had done in later years. Although it would be premature to say that they had arrived at that stage when the electric light would displace gas, there was no doubt that the former would in a short time be a very serious competitor to the gas industry. He thought that in many cases, and probably in this City of London, gas as an illuminant would be supplanted altogether. Although the electric light was more expensive than gas, the former had enormous advantages over the latter, by reason of the absence of bad atmosphere where it was used, and also on account of the deteriorating effects of gas upon paintings and other decorations, which would induce householders to adopt electricity in preference to gas. He fully believed that as the facts in connection with the electric light became more known its development would be such as to surprise them. There was no doubt that the electric light companies, as far as they knew, were earning good dividends, and there was great encouragement to all those persons connected with them to develop electric lighting generally. The success of such developments must largely depend on the manner in which the schemes were taken in hand. The Directors had taken every pains to acquaint themselves with the opinions of the leading experts in this business, and to know exactly the lines on which it could be successfully conducted. In this respect the shareholders were in a much better position than some other industries, for if one were to take an electrical enterprise to one of the large trust companies in London, those companies would have to call in special advice. The Directors of the Electric and General Investment Trust, on the other hand, had spent their time in posting themselves in the electrical industry, and would therefore, he thought, be able to judge what kind of business to foster and what to reject in the interests of the Company. He thought they would be satisfied with the small results obtained this year, and he hoped it would be his fortune to make a further statement 12 months hence, which would be a great improvement on that which he had just made. He moved

"*That the report and statement of accounts to May* 31, 1891, *be and are hereby received and adopted.*"

Mr. GEORGE HERRING, in seconding the motion, said that, if they would look at the accounts, they would find loans against consols £10,000, and cash on deposit £10,000—that was to say, the money was intact, and they could have if they liked £20,000 back in 24 hours. The business of the Company was, to a certain extent, to promote and encourage electrical undertakings, and the Directors had been very careful indeed in choosing only those which they thought of great importance. One which he might as well mention was the lighting of the City of London. The three districts had been amalgamated into one, and would be lighted by one Company, which would be brought out very shortly. The reason he mentioned this was that the shareholders in this Company would have a priority of claim in any allotment of its shares for which there would, he feared, be many applications. But if the shareholders would mention on their forms the fact that they were shareholders in this Company, the Directors would see that priority would be given to them.

The motion was carried unanimously.

Mr. KELMAN asked when the dividends would be paid, and when there was a probability of getting a quotation on the Stock Exchange.

The CHAIRMAN replied that the dividend would be paid immediately, and as to the quotation, it could not be obtained until they had a paid-up capital of more than £50,000, which was the minimum that received a quotation. He concluded by moving the dividends recommended.

Mr. B. H. VAN TROMP seconded the motion, which was carried unanimously.

On the motion of Mr. KELMAN, seconded by a SHAREHOLDER, the auditors, Messrs. Rail and Kearton, were re appointed, and, a vote of thanks having been accorded to the Chairman, the proceedings terminated.

Caustic Soda Syndicate (Limited).

The statutory general meeting of the Caustic Soda and Chlorine Syndicate (Limited) was held at Winchester House, Old Broad-street, E.C., on Friday last; Major Burnaby presiding.

The SECRETARY (Mr. Charles O. Greenwell) having read the notice convening the meeting, the CHAIRMAN said: You are all well aware that this is merely the statutory meeting which, in conformity with the Companies' Acts, must be held within four months of the registration of the company. Those who framed this Act, enforcing a meeting at such an early date, could have had little idea of the difficulties arising from the manufacture and the placing of the necessary machinery to enable us to demonstrate satisfactorily the process, which is, in itself, novel and original. It was the desire of the Board to inform you that we have absolutely manufactured caustic soda and chlorine by Mr. Greenwood's process, which is now being erected at our works in Battersea. We hope at a very early date to be in a position to ask you to meet us at the works to witness a full demonstration of this very valuable process. There appears to be little or no doubt as regards the result. Mr. Greenwood is now more than ever assured of the success of his invention, which, I need not mention, is undoubtedly one of the most important of the day. The shares offered to the public were in a short space of time over-applied for, and the whole capital allotted. The Directors have caused the patents to be applied for in those foreign countries and the colonies wherever the process is likely to be of value, and when obtained they will, no doubt, prove to be extremely valuable to this Syndicate. Although it is some little disappointment to meet you without absolutely having proved our success, I am satisfied with the working up till now, and I fully believe all parties concerned will assist in the one common object of making this Syndicate the success which we believe it will shortly prove to be.

Mr. GREENWOOD: I may say, in commencing, that this process is a very simple one; in fact, Mr. Ashton, the eminent counsel, said, in settling the specification, that it is one of the simplest processes he had ever seen. You are aware that the more simple a process is the more valuable it is, other things being equal. It does not follow, however, that because the process is simple it is easily worked. The reverse is often the case. A simple process usually requires more careful and elaborate preparation than other processes, and that has certainly been the case in this instance. I may say that all the scientific difficulties of the process were, of course, overcome before this Syndicate was formed. As regards the success of the process, it was amply demonstrated before we called upon you to subscribe one penny. It was, however, one thing to overcome the scientific difficulties, and another thing to overcome the engineering difficulties. The last three months we have overcome these engineering difficulties, and, I am glad to say, most successfully. Let me give you a fair sample of the difficulties which have caused this delay; I do not think, though, I should say delay. I do not suppose that any of you ever heard of a new process being demonstrated before the statutory meeting was held. I never knew of one. We found that, in connection with our anodes, greater delay had arisen in the progress of electrolysis than in any other thing. I claim that we have at last produced an anode, at a small expense, which is unique of its kind, and which places this Company in a position to beat any rivals, and I have no fear as regards any rivalry. After placing out our anodes to be made according to specification with two or three firms, they were returned to us, after trying their best to make them, in an altogether unsuitable condition, and we were actually obliged to take the making up of them ourselves. I myself put down the existing plant, and I invented apparatus to make these anodes, and, further than that, I introduced an improvement which I have patented only this week, which makes these anodes ten times more durable than any carbon anodes that have hitherto been made. And, therefore, the value of your patents now is considerably more than it was three months ago. Another feature in connection with this is the Diaphragm. The two main points of this process are the anode—which, I think, we have brought almost to

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perfection—and the Diaphragm. This Diaphragm has given us little or no trouble. I expected to have the most difficulty and most trouble with the Diaphragm, but it has turned out that we have had practically no trouble whatever with it. I consider it to be as perfect as it is possible to make it. The principle of its construction is based on a well-known pneumatic law. We know that all sorts of things have been done by electrolysis, with a view to the separation of the products electrolysed, and this process has been employed by every scientific inventor for the last 40 or 50 years. I claim that we have introduced a Diaphragm which, for its efficiency and cheapness, and for quality to render it serviceable, is unique of its kind, and altogether in advance of anything that has been done before. And as regards the details of the process, I am sure that when the shareholders meet us—which I hope they will do in the course of a month—they will not only be pleased, but will be astonished at such remarkable results being achieved by such simple means, for the whole thing is based upon very simple methods. We have achieved results that have exceeded my expectations, and I can only say that you have a very valuable property, and that if I were a rich man I should not mind buying every shareholder out myself.

A SHAREHOLDER, in proposing a vote of thanks to the Chairman, expressed his gratification at what he had heard, and felt confident as to the ultimate success of the undertaking.

The motion, having been seconded, was carried, and the CHAIRMAN having briefly replied, the proceedings terminated.

House-to-House Electric Light Supply Company (Limited).

The following is the second annual report of this Company's operations, being for the year ended December 31st last, to be presented to the third ordinary general meeting to be held at the Company's Central Station, Richmond-road, London, S.W., this day (Friday), at 3 p.m. :—

1. The Directors have pleasure in submitting to the shareholders (in the form now prescribed by the Board of Trade) balance-sheet and profit and loss account showing the operations of the Company from January 1st to December 31st, 1890.

2. After placing to capital account the debenture interest and loss on working to September 30, 1890, up to which date the business was being established, the net revenue account shows a credit balance of £385. 15s. 8d., which is carried forward to the next accounts.

3. The period under review has been mainly spent in building up the Company's business; the number of lights attached to the Company's circuit on January 1st being 4,520, and the number on December 31st being 13,665, pointing to the probability of good returns in future years.

4. In this connection the following statement is interesting :—

Date.	Working expenses.	Revenue.
January to June, 1890...	£1,921 0s. 7d.	... £1,373 6s. 7d.
July to December, 1890..	2,703 5s. 10d.	... 3,637 2s. 7d.

5. At the beginning of the year there were 78 houses connected to the Company's circuits, and on December 31st there were 248 houses.

The number of connected lamps, as already stated, on December 31st was 13,665, which has since been increased to 16,144 in 304 houses, whilst fully 4,000 more lights are wired or are in process of wiring.

6. The Company's mains, extending to nearly nine miles, are now laid in the following roads, &c. :—

Allan-terrace	Earl's Court-road	Nevern-square
Ashburn-place	Earl's Court-square	Newland-place
Astwood-road	Evelyn-gardens	Newland-terrace
Barkston-gardens	Fopstone-road	Old Brompton-road
Barkston-mansions	Foulis-terrace	Onslow-gardens
Bath-place	Fulham-road	Onslow-square
Bina-gardens	Gilston-road	Pembroke-gardens
The Boltons	Gledhow-gardens	Philbeach-gardens
Bolton-gardens West	Gledhow-terrace	Priory-gardens
Bramham-gardens	Gloucester-mansions	Queen's-gate
Bramham-mansions	Gloucester-road	Redcliffe-gardens
Clareville-grove	Gloucester-terrace	Redcliffe-square
Claro-terrace	Harcourt-terrace	Richmond-road
Colherne-mansions	Harrington-gardens	Roland-houses
Colherne-road	Harrington-road	Roland-gardens
Colherne-terrace	Hereford-square	Rosary-gardens
Collingham-gardens	Hogarth-road	Somerset-terrace
Collingham-place	Kempsford-gardens	Stanhope-gardens
Collingham-road	Kensington-road	Sumner-place
Courtfield gardens	Kensington-mansions	Sussex-place,
Courtfield-road	Knaresborough-place	Trebovir-road
Cranley-gardens	Lexham-gardens	Tregunter-road
Cranley-place	Marloes-road	Warwick-road
Cromwell-mansions	Moreton-gardens	Wetherby-gardens
Cromwell-road	Nevern-mansions	Wetherby-road
Drayton-gardens	Nevern-road	York-mansions

7. With a view of providing capital for the extension of the Company's business in Kensington, and in order to keep pace with the demand for the light, an issue of Seven per Cent. Cumulative Preference Shares was sanctioned in December last by the shareholders. The depressed state of the Money Market having interfered with the subscription of capital, the Directors will be glad if the shareholders will personally interest themselves in this issue and subscribe the necessary amount to admit of the extension of the Kensington station; a step which is necessary in order to comply with the obligations of the Company's Provisional Order, and to secure a satisfactory return upon the capital already invested.

8. The Directors are considering proposals for vesting the Company's interests outside the Metropolitan area in a construction company, and it is hoped that a steady annual addition to the profits of the Company will accrue from this source.

9. During the year, Mr. F. J. Burt and Mr. C. T. D. Crews resigned their seats at the Board, and the vacancies were filled up by the election of Mr. W. Page and Mr. R. A. Germaine, who are the retiring Directors, and, being eligible, offer themselves for re-election.

10. At the meeting, the shareholders will have to elect auditors for the ensuing year; Messrs. Theobald, Bros., and Miall, being eligible, offer themselves for re-election.

NEW COMPANIES REGISTERED.

ANDOVER GAS AND COKE COMPANY (LIMITED).—Registered by Waterlow Brothers and Layton (Limited), Birchin-lane, E.C., with a capital of £8,000, in £10 shares. Object: to carry on at Andover, Hants, the business of a gas company in all its branches, and also to carry on generally the business of an electric light and power company.

KINGHORN GAS LIGHT COMPANY (LIMITED).—Registered in Scotland by James Inglis, solicitor, Edinburgh. Capital, £1,200, in £1 shares. Object: to carry on the distillation of coal, oil, or other substances, so as to procure inflammable air or gas or other substances for illumination, heating, and other purposes of the town of Kinghorn, Fifeshire, and suburbs, or such parts thereof as may be deemed expedient; to supply electricity there; to sell gas and electricity, and the coke, tar, and other products arising from the distillation of coal, oil, and other substances, and to manufacture such products into articles of commerce.

OGMORE VALLEY ELECTRIC LIGHT AND POWER SUPPLY COMPANY (LIMITED).—Registered by Jordan and Sons, 120, Chancery-lane, W.C., with a capital of £10,000, in £5 shares. Object: the carrying on in the Ogmore Valley, and elsewhere in the county of Glamorgan, the business of an electric light company in all its branches.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the past week amounted to £5,670.

CALEDONIAN TELEPHONE COMPANY, LIMITED.—A prospectus of this Company has been issued. The Company has been registered with a capital of £50,000, divided into 50,000 shares of £1 each, with power to increase. The present issue is for 10,000 shares of £1 each, payable 5s. on application, 5s. on allotment; balance not arranged for in prospectus. The interim secretary is Mr. William Barton, of 109, St. Vincent-street, Glasgow. The Company has been formed to acquire from Mr. A. Erskine Muirhead, of Cart Forge, Crossmyloof, and 109, Hope-street, Glasgow, the business carried on by him of supplying telephonic communication among traders generally, and more especially of connecting branch offices and departments with the head offices in connection with collieries, railway companies, iron founders, mill owners, public works, &c. The prospectus states that the Company commences business free from all patent duties, royalties, or other heavy charges against capital. The objects of this Company at the outset will be :—(1) To take over and thereafter develop the business commenced by the vendor of supplying private wires between central offices and their branches, and connecting different departments of works; (2) To enter into contracts for the maintenance of private wires; (3) To establish telephone exchange communication in towns; (4) To carry on the business of buying and selling telephones. The instrument used by the vendor is the French telephone, as made by The Société Général des Téléphones, and which is capable (the prospectus further states) of speaking a distance of over 500 miles. The stock, plant, and effects of the vendor will so far as necessary for the Company's business be taken over at a valuation. No price has been paid for goodwill. The vendor is in negotiation with a large number of firms for telephonic communication, and those contracts will be taken over by the Company. *While personally fully satisfied with the statements and estimates contained in the Prospectus, the directors do not in any way warrant them.* Prospectuses can be had of the secretary.

CITY AND SOUTH LONDON RAILWAY COMPANY.—The traffic receipts of this Company for the past week amounted to £860. The aggregate receipts for the half-year to date are £17,779.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—Notice is given that the coupon on this Company's Five per Cent. Australian Government Subsidy Debentures, due on July 1st prox., will be paid on and after that date at Messrs. Barclay, Bevan, and Co., 54, Lombard-street, E.C. Coupons must be left three clear days for examination.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended June 12, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,027.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, June 10.	Price Wednesday, June 17.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending June 17. Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
£1,300,980	Stock	12/0	Anglo-American	46½ 47½	46 47	6 2 4	Jan., Apr., July, Oct.	45½	..
£2,849,510	Stock	21/0	Do. Preferred	84 85	84 85	6 15 4	" "	85	84
£2,849,510	Stock	..	Do. Deferred	11 11½	11 11½	..	..	..	..
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99 102	99 102	3 18 5	January and July	100	..
130,000	£10	3/0	Brazilian Submarine	11¾ 12¼	11¾ 12¼	6 2 5	Mar., June, Oct., Dec.	12 1/16	..
£69,200	£100	5%	Do. 5 per Cent. Bonds	101 104	101 104	4 16 2	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	104 108	104 108	4 12 7	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	106 108	106 108	6 0 4	April and October	107⅜	..
16,000	10	8/0	Cuba Submarine	10½ 11½	10½ 11½	6 19 2	February and August	..	..
6,000	10	10%	Do. Preference 10%	16½ 17½	16½ 17½	5 14 3	" "	..	..
12,931	5	3 3/20	Direct Spanish (£4 paid)	3⅜ 4¼	3⅜ 4¼	6 11 9	April and October	..	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	10¼ 10⅜	10⅜ 10⅝	6 11 9	Jan., Apr., July, Oct.	10⅝	10½
400,000	10	2/6	Eastern	14½ 14⅝	14½ 14⅝	4 8 2	" "	14⅝	14½
70,000	10	6%	Do. 6 per Cent. Preference	15 15½	15 15½	3 17 5	" "	..	..
£1,200,000	Stock	6%	Do. 4 per Cent. Mort. Debenture Stock	106 109	106 109	3 13 5	May and November	107	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	107 110	4 10 11	February & August	107½	..
250,000	10	6/6	Eastern Extension	14¾ 15¼	14¾ 15¼	4 11 10	Jan., Apr., July, Oct.	15 7/16	14 15/16
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock	105 108	105 108	3 14 1	..	..	..
£85,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103 106	103 106	4 14 4	January and July	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	103 106	103 106	4 14 4	" "	..	..
180,227	10	2/6	Globe Telegraph and Trust	9⅜ 9⅝	9½ 9⅝	5 5 1	Jan., Apr., July, Oct.	9 11/16	9½
180,042	10	6%	Do. 6 per Cent. Preference	15 15½	15 15½	3 18 8	" "	15½	14⅞
150,000	10	8 3/4% fr 90	Great Northern	18½ 19	18½ 19	4 9 6	Jan., April, and July	18¾	18 11/16
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105 108	105 108	4 12 7	March & September	..	..
17,000	25	37/6	Indo-European	39 41	39 41	4 11 6	May and November	40½	40
38,348	10	5/0	London Platino-Brazilian	6½ 7⅞	6½ 7⅞	6 0 0	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106 109	106 109	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's	8 8½	8 8½	4 14 1	April and October	..	..
3,381	£100 Cert.	6%	Submarine Cables Trust 6%	114 118	114 118	5 1 8	" "	..	..
15,609	10	4/0	West African Telegraph	8 9	8 9	5 11 1	January and July	..	..
£281,400	100	5%	Do. 5 per Cent. Debentures	95 98	95 98	5 2 0	March & September	..	..
30,000	10	2/0	West Coast of America	3½ 4½	3½ 4½	..	January and July	..	..
£150,000	100	8%	Do. Debentures 8% 1902	100 105	100 105	7 12 5	June and December	..	..
88,321	10	9d.	West India and Panama	3 3½	2¾ 3	..	..	3 3/16	2¾
34,563	10	6/0	Do. 1st Preference 6%	11½ 12	10⅝ 11¼	5 6 8	May and November	11¾	..
4,669	10	34/6	Do. 6 p. c. 2nd Pref.	9½ 10½	9½ 10½	5 14 3	" "	..	..
61,683	15	9/0	Western and Brazilian	11 11½	11 11½	6 10 7	" "	11½	..
30,364	7½	1/6	Do. 5 per Cent. Cumulative Preferred	6½ 7	6½ 7	5 7 3	"	..	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	4½ 5	4½ 5	..	..	4½	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	104 107	103 106	5 13 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103 106	103 106	5 13 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	117 122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bond	100 104	100 104	5 15 5	March & September	..	..
			TELEPHONES.						
224,850	14/0	0/4½	Consolidated Telephone Const. & Maintenance. xd	½ ⅝	1/16 1/8	..	May and November	..	..
220,000	£1	4·76	Oriental (11s. paid)	¼ ⅜	¼ ⅜	5 2 11	Yearly	..	..
438,984	5	2/6	National	4⅜ 4½	4½ 5	5 10 0	June and December	5	4½
15,000	10	6/0	Do. 6 per Cent. Cumulative 1st Pref.	12¼ 12½	12¼ 12½	4 14 1	" "	..	..
15,000	10	4/9 3/8	Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd)	11⅜ 12¼	12 12½	3 16 10	" "	12½	12
350,000	£100	4½%	Do. Debenture Stk. 4½% Prov. Cert. (fully pd)	104 106	104 106	4 4 11	..	105¼	104½
58,000	5	1/0	United River Plate	2½ 3½	2½ 3½	..	January and July	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85 95	85 95	5 5 8	..	..	..
£3,200	100	..	Do. 7 per Cent. Debentures	..	..	..	—	..	..
			ELECTRICITY SUPPLY COMPANIES.						
1,000	£50	..	City of London Electric Lighting Shares (£25 pd)	30 34	36 37	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	4½ 5	4½ 5	..	..	..	..
5,322	£5	..	House to House Electric	4½ 5½	4½ 5½	..	..	..	..
30,000	£5	..	Liverpool Electric Supply (£3 paid)	2⅜ 2⅝	2⅜ 2⅝	3 13 1	..	..	..
111,000	5	..	London Electric Supply	2 2⅛	1⅞ 2⅛	..	..	..	..
43,900	10/0	2/0	Metropolitan Electric Supply (£9 paid)	8⅞ 9⅛	8⅞ 9⅛	4 7 7	..	9⅛	8 13/16
7,730	£5	..	St. James' and Pall Mall	5½ 6½	5½ 6½	—	..	..	..
..	..	7%	Do. 7% Preference	⅝ ¾ prem	¾ 1	..	..	..	..
42,853	5	..	Westminster Electric Supply (£5 paid)	4¾ 5¼	4¾ 5¼	..	..	5	4 13/16
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	..	Brush Electrical Engineering	2⅝ 2⅞	2½ 2¾	..	..	2 7/8	2½
69,993	2	1/1	Do. 6 per Cent. Preference	1⅝ 1⅞	1⅝ 1⅞	6 8 0	June and December	1 15/16	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	4 5	4 5	7 0 0	January and July	..	..
17,139	5	..	Edison and Swan United	..	..	..	—	..	..
45,000	10	6%	Electric Construction	4½ 5½	3 4	..	—	3 1/8	2½
70,000	2	10/0	Elmore's Patent Copper Depositing	2¼ 2⅝	3 3½	..	—	3 1/16	2⅝
20,000	5	..	Fowler-Waring Cables (£4 paid)	2 3	2 3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	18½ 19½	18½ 19½	5 2 7	February & August	19¼	..
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103 105	103 106	..	March & September	..	..
11,334	£10	6/1	International Okonite Limited Ordinary	7½ 8½	7½ 8½	11 15 3	..	..	..
11,334	£10	5/0	Do. Preference	9½ 9⅝	9½ 9⅝	8 4 1	..	..	..
78,949	5	2/1½	Swan United (£3. 10s. paid)	4½ 5	4½ 5	6 19 10	May and November	4⅝	..
37,350	12	36/0	Telegraph Construction and Maintenance	46 48	46 48	5 0 0	March and July	47	46
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	102 105	103 106	4 14 4	January and July	104½	..
..	£5	..	Woodhouse and Rawson Ordinary (£3 paid)	2½ 2⅝	2½ 2⅝	..	..	..	..
—	£5	..	Do. Preference (fully paid)	3⅝ 4⅛	3⅞ 4⅛	..	..	..	..
			RAILWAYS.						
50,000	£10	..	City and South London Railway	4 5	4 5	..	..	—	—

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

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NOTES.

The Central London Railway scheme was thrown out last year owing to an opposition of a very varied description. Amongst other alarms it was urged that mischief would be wrought on the foundations of St. Paul's, and that the dome would be in grievous jeopardy. This year the Dean and Chapter of St. Paul's were, we believe, propitiated by an alteration in the proposed site of the Cheapside station, and in consequence of this and many other similar concessions, the preamble has been proved. We can only hope that the passage of the Bill will now meet with no further impediment. It has been suggested that the direct competition of this line may cause the omnibus routes to be diverted through the less important thoroughfares, and that the streets immediately above the railway will be thus relieved. The recent strike has shown Londoners what a boon such a relief would be, and the short experience which they have recently enjoyed has probably told strongly in favour of the Central London Railway.

The outcome of a meeting which was held some two months ago to express dissatisfaction with the present telephone service in London was, as we reported at the time, the formation of an Association for the Protection of Telephone Subscribers. A circular has now been issued from the offices of the London Chamber of Commerce, in which it is stated that the Committee confidently feel that great benefits can be obtained by united action, and that it is only by combination that increased efficiency and a reduction in rental can be attained. Unless well backed up by the Post Office, it is difficult to see how this body intends to act with effect. The lapse of the telephone patents will hardly affect the London service of the National Telephone Company to the slightest degree; the property which they own, and the position which they have acquired, has long since ceased to consist in any monopoly of instruments, but in the system of wires and exchanges by which any one individual, if he has the necessary patience, may be put in connection with any other of the 6,419 subscribers. The "inefficiency" of the service presumably refers to the many inconveniences, such as delay in "getting through," "cross-talk," and the maddening "ticker," but constant improvements are being made, and the Company is always ready to investigate complaints, and frequently succeeds in removing the trouble. We are aware that many important houses of business decline to avail themselves of the present telephone service on account of such defects, and shrink from risk of verbal misunderstandings. Our Copenhagen correspondent justly boasts, in another column, of the wonderful service in Stockholm, which, already having the largest number of telephones per hundred inhabitants, proposes an annual subscription of 11s. per annum, and a fee of 1½d. for each message sent. But we can never expect that this figure will ever be approached in London, if only on account of the price of labour and way-leaves.

Of the many muddles which municipal authorities have made in dealing with the question of electric light, none has been so complete as that in which the Cambridge Town Council has floundered In the first place, Dr. Fleming was asked for advice, the next step was to invite tenders in accordance with his general recommendations for a transformer system of distribution, no elaborate specification being given, but a free hand being allowed to each firm to recommend what it thought best. Certain tenders were recommended, and a local architect furnished plans and an estimate for a building, based upon the requirements of the contractors, his estimate being £4,900. Tenders for the erection were invited from local builders, and the lowest was found to be £11,260. Thereupon it was decided to abandon the whole scheme.

A committee of the Town Council, imagining that if they actually saw the wheels go round they would learn more than any consulting engineer could teach them, started off on one of those tours in which such gentlemen delight. We have read their report, but fail altogether to understand why they approved so highly of the Parsons steam turbine; possibly the wheels went round at a more surprising speed than elsewhere. Mr. Parsons estimated the building and equipping of a suitable station at £13,500. Dr. Fleming could not recommend this ingenious motor (which doubtless is excellently adapted for certain purposes) as an economical steam engine possibly because no satisfactory information on this point has as yet been published. But a different opinion is held by Prof. Garnett, who takes a kindly interest in the Parsons engine, since it is used at Newcastle by the local supply company with which he is connected. Dr. Porter sensibly suggested that Prof. Kennedy should be referred to, to decide the question, and outside the ranks of engine builders, no better man than Prof. Kennedy could be selected. But the committee have decided to proceed with the muddle which they call their scheme, at a cost not exceeding £26,500, and to engage Prof. Garnett as consulting engineer.

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In the current number of the *Electrical World* of New York appears a preliminary statement in connection with a new alternate current motor system due to the joint efforts of Mr. William Stanley, jun., and Mr. J. F. Kelly. The authors propose to overcome the difficulties encountered in working alternate current motors, owing to the self-induction possessed by the armature and field magnet circuits, by the device of using condensers of suitable capacity in shunt or series with the coils. They claim to have so far succeeded in the application of this idea that they can supply alternating currents to the ordinary type of motor, possessing great self-induction, and develop the field magnetisation in the same manner as though the motor were supplied with direct currents of constant value. The practical details of the work which these engineers have actually carried out will, no doubt, prove of great interest as soon as it is published, but the present communication contains very little information that is really novel. The authors acknowledge that the possibility of annulling self-induction by capacity has been previously pointed out, and state that the theoretical portion of their work was completed before the publication of the discussion on the Ferranti effect which has recently taken place in our columns and elsewhere. But the idea is well known, not only to theorists but to practicians, for it has already received important applications in telegraphy. The writers suggest that the troublesome currents in telephone lines, due to induction and leakage from neighbouring electric light and power circuits, might be suppressed by inserting a condenser in the line. A condenser transmits a current more readily as the frequency of the alternations is increased, and thus may act as a conductor for the rapid telephone currents, and as an insulator for the slower currents due to the various disturbing influences. This device is, however, essentially the same as that often employed on combined telegraph and telephone lines.

Much has been written at various times about the mathematical peculiarities of combinations of coils and condensers, but before they can be turned to practical account many difficulties have to be surmounted. One of the greatest of these is the production of suitable condensers at a reasonable cost. Another arises from the fact that the self-induction of all iron cored cir cuits varies considerably with the current, so that any method dependent upon the adjustment of a condenser to neutralise self-induction must be so arranged that the capacity of the condenser used can be altered when necessary. A third difficulty arises from the necessity of increased insulation. The voltage required to produce a given current in an inductive coil is dependent merely upon the coil itself; it cannot be altered by any external arrangement of condensers. It is true that by means of the latter a larger current can be produced in the coil by a given voltage supplied by the leads, but this can only be from a resonance effect in consequence of which the voltage on the coils rises to a greater value than that supplied by the distributing mains.

Society of Arts.—The Council of the Society of Arts have awarded a silver medal to Prof. William Robinson for his Paper on "The Use of Petroleum in Prime Motors."

Postal Appointment.—Mr. J. J. Towers, sorting clerk and telegraphist, of Kirby Lonsdale, has been appointed Postmaster of Cockermouth.

Tangier.—The Spanish "Compañia Transatlantica" have decided to introduce the electric light into Tangier, and the material for this purpose is expected to arrive very shortly.

Erratum.—In the article on "Magnetism in Iron and other Metals," No. XLIII. (*The Electrician*, June 19th, page 182), in the second last line: for "40π" read "$0{\cdot}4\pi$," and for "125·66" read "1·2566."

Reminiscences of Faraday.—"Dagonet," in the *Referee* of the 21st inst., relates some extremely interesting personal reminiscences of Faraday and his connection with the Sandemanians.

Proposed Electric Railway at Blankenburg.—It is proposed to run an electric railway between Blankenburg and Thale, the current for the purpose being supplied by the Blankenburg Electricity Supply Company.

Electric Transmission of Power Project.—A project is on foot for supplying power transmitted by electricity from the Argen, near Laimrau, to Limnau, Ravensburg, Weisenau, Tettrang, Meckenbeuren, and Weingarten.

Appointment.—Mr. J. T. Nicolson, B.Sc. (Edin.), at present Professor Ewing's Demonstrator in the University of Cambridge, has been appointed to the Chair of Mechanical Engineering in the McGill University, Montreal, Canada.

African Direct Telegraph Company (Limited).—Notice is given in our advertisement columns that the coupons on this Company's Four per Cent. Mortgage debentures to bearer, due July 1st next, will be paid on and after that date, at the Alliance Bank, Bartholomew-lane, London, E.C.

Electric Traction in Paris.—La Société des Tramways de Paris et du Département de la Seine are about to start a regular service of electric cars from the Rue Lafayette, near the Opera, to St. Denis, over a line having some very steep gradients. The electrical rolling stock will consist of 20 fifty-four passenger cars.

Atlantic Cable Competition.—As an instance of the extreme competition amongst the Atlantic companies for the telegraph traffic, it may be mentioned that the Direct United States Cable Company have issued a specially designed card message form, for use on board the Atlantic liners, to be filled up by those who wish to cable, and then handed to the purser on arrival at Liverpool, or to their attendant, whose photograph appears on the back of the card.

Cambridge.—The Town Council were engaged for a considerable time on Tuesday last week in discussing the report of their Electric Lighting Committee, and ultimately decided to accept the recommendation to adopt Mr. Parsons's system, and further authorised the committee to conclude contracts for carrying out the electric lighting of the town, at a cost not exceeding £26,500, on the understanding that the installation should suffice for 10,000 lights of 8-c.p., or their equivalent. Prof. Garnett, of Newcastle, was also appointed consulting engineer.

An Electric Light Installation for the Greenwich Observatory.—In view of the advantage resulting from the use of electric lighting for the photographic, equatorial, and for other instruments, the Astronomer-Royal considers it very desirable that an electric light installation should be provided for the Greenwich Observatory, so that this method of lighting, which is specially adapted to the requirements of an observatory, may be applied to the instruments generally. The system now in use is that of charging storage cells from primary batteries.

Automatic and Multiplex Telegraphy.—Mr. Gisborne recently read an interesting Paper on the above subject before the third section of the Royal Society of Canada. Mr. Gisborne is reported to have stated that 3,000 words per minute had been transmitted by a copper wire line, 355 miles in length, between New York and Washington, and 800 words over a similar wire 1,000 miles in length, between New York and

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Chicago, and that 600 words per minute have been transmitted by repeaters beyond that distance.

The Lighting of the City.—At the last meeting of the Commissioners of Sewers the report of the Streets Committee was presented, which contained a reference to the proposed transfer of the undertakings in regard to the City electric lighting to a new company, to be formed under the title of "The City of London Electric Lighting Company." The Committee recommended that this transfer should take place providing the Commissioners were satisfied with the particulars. After some discussion, and the proposal of a couple of amendments, the report was adopted.

Obituary.—William Edward Weber, the eminent German physicist and the co-worker of Gauss, died at Göttingen on Wednesday at the age of 86. We hope next week to give a full obituary notice of this great worker in the electrical field.—The death is announced of Prof. L. V. Lorenz, of Copenhgen, well known for his electrical work. In 1882 Prof. Lorenz represented Denmark on the International Committee which met in Paris to fix the electrical units. He was also the author of several standard works on light and heat. The Lorenz and Jürgensen dynamo was awarded a gold medal at the Paris Electrical Exhibition. Prof. Lorenz was in his sixty-third year.

The British Association.—A large and influential meeting was held at Edinburgh, last week, to consider the arrangements which ought to be made for the visit of the British Association to that city next year. The Lord Provost presided. A local executive committee was chosen, and Mr. A. Gilles Smith was appointed honorary local treasurer. In a letter from Mr. Griffiths, secretary of the Association, it was stated that Sir Archibald Geikie, who will preside over the Edinburgh meeting, was in favour of the meeting being held early in August. A considerable majority, however, voted in support of a proposal that the meeting should begin on Wednesday, September 28th.

Municipal and County Engineers' Association.—The annual meeting of the Incorporated Association of Municipal and County Engineers commenced yesterday. To-day Mr. W. H. Preece will deliver an address "On the Relative Merit and Cost of Gas and Electricity for Lighting Purposes;" and this will be followed by a Paper from Prof. H. Robinson, entitled "Electric Lighting by Municipal Authorities." Several visits of inspection to various works will occupy the attention of the members in the afternoon; and the whole of Saturday will be similarly employed. Among other places to be visited that day will be the works of the London Electric Supply Corporation at Deptford.

Carlow.—The town of Carlow was successfully lighted up by Messrs. J. E. H. Gordon and Co. at an early hour yesterday morning. The electricity is generated by water-power situated at Milford, five miles distant, and is conveyed to the town by overhead wires at 2,500 volts pressure. Transformers fixed on the posts in the town reduce the pressure to 50 volts, and deliver the electricity to a system of bare copper low-tension mains carried on the same posts. The arc and incandescent lamps are both attached to this. The low-tension mains extend through four and three-quarter miles of streets, and the plant is sufficient for the whole public and private lighting of the town. The work was commenced in December last.

Damage by Lightning.—On the 3rd June, a thunderstorm of great violence broke over Vienna shortly before noon and lasted for more than three hours. Some 26 houses in different parts of the city were struck. A woman and two children were killed, and many persons received injuries.—On Monday evening last, a heavy thunderstorm burst over Gloucester. The lightning struck the vane of St. Nicholas' Church, one of the oldest in the city, and set fire to the top of the roof.—According to a Reuter's telegram from Budapest, eighteen field labourers, overtaken by a thunderstorm in the Oedenburg district, sought shelter by the side of a hayrick, which was immediately afterwards struck by lightning. Three of the men were killed on the spot, and the others were stunned.

Foreign Telegrams.—The Postmaster-General has issued the following notice:—"On and from the 1st of July the rates for telegrams to many countries will be reduced, as arranged at the International Conference held in Paris. Examples:—Austria, from 4½d. to 3d. a word; Hungary, from 4½d. to 3d.; Gibraltar, from 5½d. to 4½d.; Italy, from 4½d. to 3d.; Malta, from 7d. to 6d.; Sweden, from 5d to 4d.; Norway, from 4d. to 3½d.; Russia, from 6½d. to 5½d.; Portugal, from 5½d. to 4½d.; Spain, from 4½d. to 4d.; Switzerland, from 3½d. to 3d.; Canary Islands, from 1s. 7½d. to 10d.; Java, from 6s. 10d. to 6s.; Singapore, from 6s. 5d. to 5s. 9d.; Penang, from 5s. 7d. to 5s.; Senegal, from 2s. 10½d. to 1s. 6d.; St. Paul de Loanda, from 9s. to 8s. 7d. At the same time the fees for signalling ships at foreign semaphore stations will be reduced from 1s. 8d. to 10d."

Mutual Telephone Company.—The number of subscribers on this Company's Manchester exchange actually speaking on June 19th was 366. They are being added to daily at the rate of 25 per week. The progress made might be quicker, but it is not desired to have more than 500 talking on July 30th, as after that date the magneto transmitters now being put in are to be replaced by carbon ones. We understand that the Mutual Company will be prepared on July 31st with a sensitive and efficient transmitter, made in accordance with one of the designs figured in Edison's tension-regulator patent, which expires on July 30th. Arrangements are being made to join up 50 subscribers per week after the change of transmitters has been effected, and erect trunk lines to, and open exchanges in, Bolton, Oldham, and many of the other Lancashire towns.

St. Pancras Vestry.—At the last meeting of this vestry the Electrical Committee reported that they had been endeavouring to obtain suitable premises for the sub-station required between the works and the extreme northern limit of supply. The engineer had submitted a plan for constructing a chamber for the purpose under the roadway of High-street, south of the Cobden statue. The space to be taken would be 30ft. by 16ft. The roadway to be repaved with the same sets that the Committee found there. The proposition was carried. It was also decided to issue advertisements for a competent engineer and electrician of general business experience as general manager, at a commencing salary of £250 per annum. Candidates to be between 25 and 45 years of age, and be subject to the usual conditions of the Vestry regarding appointments.

Telephone Licences.—Dr. Cameron asked the Postmaster-General, on Friday evening last, whether the patents for the more important telephones in use in this country expired in July next; and, if so, whether he was now in a position to announce the decision of the Post Office as to granting licences for telephone exchanges to applicants proposing to introduce loud-speaking and other improved forms of the telephone. Mr. Raikes, in reply, stated that it was the fact that one of the more important telephone patents expired in July. The question of the relations of the Post Office to the telephones was, he said, one of great complexity, as well as of great importance. It was more than a departmental question. The subject had been occupying the anxious attention of Her Majesty's Government, but they had not come to any final arrangement as to the course to be pursued.

The Electrical Equipment of S.S. "Scot."—The extent to which electric lighting is carried out, not only on the huge Atlantic liners, but on board all modern mail steamers, is well illustrated by the electrical equipment of the Union Company's fine twin-screw steamer "Scot" (6,850 tons), built by Denny Bros., of Dumbarton, for the South African mail service. The electric light installation consists of 650 16 c.-p. incandescent lamps, with special fittings made by Messrs. M'Geoch, of Birmingham, and four King-Brown four-pole 200 ampere dynamos. The main and auxiliary switchboards were made by Denny Bros. The measuring instruments have been supplied by Siemens Bros. In addition to the electric lighting installation a number of electric fans have been put up, and the Blackman Ventilating Company also supply several large fans for the ventilation of the engine rooms.

Berlin Electric Lighting Statistics.—The *Elektrotechnische Rundschav* gives the following particulars as to electric light in Berlin. Leipzigerstrasse is lighted by means of 36 arc lamps, which burn until midnight. In the Unter den Linden, Opernplatz, Lustgarten, and Kaiser Wilhelmplatz are 108 more arcs,

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of which 60 burn the whole night, whilst 48 are extinguished at 12 o'clock. Twelve arcs serve to light the Schillingsbrücke and a part of the Stralauerplatz. The total number of arcs utilised for public lighting is consequently 156. At the end of March, 1890, 4,944 arcs and 80,788 glow-lamps were being run in Berlin. Of these the Berliner Elektricitatswerke were supplying from their central station 1,832 private arcs and 43,215 incandescents. The remaining 3,112 arcs and 37,573 incandescents were supplied from 262 isolated plants, 171 of which were driven by steam and 91 by gas.

The Germain Magneto-Telephonic Transmitter.—In a note in the *Comptes Rendus* of June 8th, M. P. Germain says "The mouthpiece of a magneto-telephone transmitter may be divided into a number of smaller mouthpieces, each corresponding to a distinct telephone armature above the opening of the air chamber. The emission of a single voice thus gives rise in all the columns of air, and on all the telephone armatures, to pressures proportional to the total surface of the armatures actuated. Each armature of the Bell electro-magnet, of which it is a part, thus develops similar, if not equal, induced currents in all the distinct and equal circuits composing the transmitter. If we connect the negative end of the first coil to the positive end of the second, and the negative end of the second to the positive end of the third, and so on to the end, and if we arrange all these circuits in series in a telephone line, it is possible to telephone to great distances without a microphone, without a constant battery, and without an Edison coil."

A Sensitive Electrical Alarm.—At the last meeting of the Académie des Sciences, MM. G. and L. Richard described an electrical alarm devised by them for the purpose of responding to variations in the pressure of a current of air or gas. The alarm is extremely sensitive, and will act for variations of a few hundredths of a millimetre of water. The apparatus consists of a metallic box communicating with the flue, through which the gas is flowing, by a small tube. This tube is closed inside the box by a light metal valve, the movements of which open and close an electric alarm circuit. By altering the position of the box with regard to the vertical, the sensitiveness of the apparatus is more or less modified, and beyond a certain point the apparatus may be made to indicate an increase of pressure. MM. Richard propose to fix this device to ventilating tubes or to flues. In some cases it may be necessary to have an additional automatic device to prevent purely momentary depressions from affecting the instrument. Where required the alarm circuit could be made to include an electro-magnet which should attract a bar of soft iron actuating a train of clock wheels, which, when a certain definite time had elapsed, should allow the alarm to ring.

The Dielectric Properties of Mica at High Temperatures.—In a Paper recently read before the Académie des Sciences, M. E. Bouty described some investigations carried out by him with regard to the dielectric properties of mica at high temperatures. The result of M. Bouty's researches is to demonstrate the almost complete invariability of the dielectric constant of mica, which, between 0° and 300°C., certainly does not alter by one-fiftieth of its original value. Above 300°C. experimental complications occur, and tend to obscure the result. M. Bouty made use of silvered sheets of mica, and when the temperature was carried beyond 300°C., the silver was attacked if in contact with the air, and the mica was soon covered by a transparent electrolytic film. This defect may be minimised by covering the silver with a fairly thick layer of copper. Above 300°C. the charge furnished by the battery is no longer entirely recoverable, which is doubtless due to the formation of the conducting film, since the conductivity at the same temperature rapidly increases if the application of the heat is prolonged, and the conductivity is maintained on cooling until the superficial hygrometric layer has been washed away in alcohol. It is possible that between 300° and 400°C. mica may possess some slight specific conductivity. However that may be, says M. Bouty, the resultant conductivity between 300° and 400°C. is negligible for charges of brief duration.

Polytechnic Institute in Chelsea.—The movement for the establishment of a Polytechnic Institute for South-West London, north of the Thames (including the districts of Fulham, Chelsea, St. George's, Hanover-square, Kensington, and Westminster), commenced in 1888. The Charity Commissioners promised to devote £50,000 to the endowment and support, on condition that a like sum of £50,000 should be contributed for its site, building, and equipment. A site in Manresa-road, Chelsea, was given by Earl Cadogan, and approved by the Charity Commissioners as convenient for the district. The value of this site is estimated at £10,000; and the amount to be raised by subscription was thus reduced to £40,000. Up to the present time the efforts of the Committee towards the raising of the required £50,000 have resulted in a total of £32,000, including the value of the site before mentioned. The plans recently selected include accommodation for—1. Technical and commercial schools and science and art classes for young men and women above 15 years old. 2. Gymnasium, swimming bath, lecture and reading rooms, music, and various forms of recreation. 3. Day schools and evening classes for boys and girls between 13 and 15 on leaving the elementary schools. Only a technical library is included, as the new buildings of the Chelsea free libraries adjoin the proposed Institute, and will be utilised by its members.

Electric Traction and the Telephone.—On June 2nd the Supreme Court of Ohio gave judgment in the case of the Cincinnati Incline Plane Railroad Company *v.* the City and Suburban Telegraph Company. This action has excited considerable attention in the United States, involving, as it does, the two great interests of telephone exchanges and electric street railways. The action was brought by the telegraph or telephone company to restrain the Incline Plane Railroad Company from constructing and running their electric railway by the use of the Sprague—single trolley system—on the plea that the "earth return" interfered with the use of the telephone, and almost destroyed their business. The Telephone Company claimed the first right to the earth, with the use of it for their return circuit. The matter could be remedied by one of two ways. First, by the railway putting in what is known as the double trolley system, by the use of which the telephone would not be interfered with. Second, by the Telephone Company, instead of using the earth for the return circuit, putting in "metallic circuits." The Supreme Court upheld the theory that the street was primarily intended for the use of the general public for the purpose of travelling and transporting goods, and the fact of motive power, which facilitates the object, being changed to something which might interfere with a subordinate use of the highway, ought not to make any difference in that regard.

The Electrolysis of Sulphuric Acid.—A further communication upon the new peroxide of sulphur, SO_4, by Prof. Traube, of Breslau, will, says *Nature*, be found in the current number of the *Berichte*. This interesting substance is obtained when solutions of sulphuric acid containing at least 40 per cent. of acid are subjected to electrolysis, as a crystalline deposit upon the anode. The crystals were first observed some time ago by Berthelot, but were considered by him as identical with the oxide S_2O_7, which he had previously obtained by the action of the silent electrical discharge upon a mixture of sulphur dioxide and oxygen. Prof. Traube, however, finds that the substance obtained at the anode in the electrolysis of 40 per cent. solutions of sulphuric acid is represented by the formula SO_4, and is quite a different substance from Berthelot's S_2O_7. SO_4, however, in spite of its ready decomposition into oxygen and sulphuric anhydride, is but a weak oxidising agent. But under certain circumstances it acts as a powerful reducing agent. For instance, if an emulsion of peroxide of lead in 40 per cent. sulphuric acid is brought in contact with a quantity of similar acid which has been been subjected to electrolysis so as to charge it with SO_4, a rapid evolution of oxygen gas occurs, and the peroxide of lead is converted into ordinary sulphate of lead. Prof. Traube regards sulphur peroxide as built up on the type $SO_2(O_2)$, resembling hydrogen peroxide, H_2O_2. He considers that Bertholet's oxide S_2O_7 is a molecular compound of SO_3 and SO_4, for it does not dissolve in water without decomposition, breaking up into sulphuric anhydride and oxygen, which is evolved. On the other hand, it appears, like SO_4, to be perfectly stable in a moderately concentrated solution of sulphuric acid.

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THE HISTORICAL DEVELOPMENT OF THE INDUCTION COIL AND TRANSFORMER.

BY DR. J. A. FLEMING, M.A.

(Continued from Vol. XXVI., page 417.)

§ 7. **Callan's Further Researches.**—In the *Philosophical Magazine* for December, 1836, Prof. N. J. Callan made further mention of his auto-induction coils, giving also a description of an improved form of galvanic battery. He wound, on an iron bar about two feet long and an inch thick, two coils of insulated wire, each about 200ft. long. These insulated wires were joined together in series, and the extremities of one wire were put in connection with a battery of 14 cells; on taking hold of the ends of the whole length of 400ft. of wire and breaking the battery circuit, a very sharp shock was felt. He concluded that if about 2,000ft. of wire were so coiled on a bar, and the first 200ft. of this wire connected to a battery, a still greater shock would be received if the ends of the whole 2,000ft. were touched, and the battery contact broken. Twenty-one years afterwards he returned again to the subject of induction apparatus, and in a long Paper, communicated to the British Association at its Dublin meeting in 1857, and reprinted in the *Philosophical Magazine* for November, 1857, Callan described many experiments he had made in his efforts to improve the induction coil and exalt its power. Referring first to the induction coil made at Maynooth College in 1836, and to one like it sent to Mr. Sturgeon in the summer of 1837, he establishes his claims to priority in the matter of the invention of an induction coil, having two *separate* wires, one thick and the other thin, by means of which a *quantity* current could be made to produce an *intensity* current. This 1857 Paper is occupied chiefly in advocating the use of an induction coil, with a secondary circuit made of insulated iron wire, and such a coil he showed to the British Association, in which the secondary circuit consisted of 21,000ft. of iron wire, about ·01in. diameter. His arrangement apparently consisted in using a secondary circuit of insulated iron wire rolled up tightly into a cylindrical form, and which formed not only the secondary circuit, but also the iron core of the primary. The primary circuit, consisting of insulated copper wire, was wound over and outside of the iron wire secondary, and the secondary circuit thus fulfilled at once the functions of core and secondary circuit. In one form of coil described the circuits were alternately overlaid. First an iron wire secondary circuit, then a copper wire primary; then over this another iron wire secondary, and a further copper wire primary. The primary circuits were to be joined in series, and the iron wire secondaries in parallel, with the object of obtaining "considerable quantity" in the secondary currents. It is suggested that in this way it would be possible to procure current enough to operate an arc light between carbon poles. One form of induction coil suggested consisted of an iron wire secondary coil wound up tightly into a helix; and on this, considered as an iron core, the copper wire primary was wound; over this copper circuit another iron wire circuit was coiled, and the two iron wire circuits were joined up in series, so that the copper wire primary acted inductively on both, and generated induced currents in each in the same direction. Reasons are given in this Paper which led the writer to consider that this insulated iron wire secondary circuit had advantages over a secondary circuit of copper wire, and an independent longitudinally divided iron core, as introduced by Backhoffner. Callan explained with great clearness that the principle of joining together the secondary circuits of a number of coils in parallel is the right method to adopt to obtain a secondary current of sufficient strength and electromotive force to produce an arc light, and he may, therefore, be credited with the knowledge at that date of the mode of adding up either the electromotive forces or the currents in the secondary circuits of a number of distinct induction coils. It is not quite equally clear whether he ever arranged his coils with primary circuits in parallel also. The same Paper also contains suggestions as to mode of manufacture of condensers for induction coils, and certain advantages are claimed for condensers made of iron plates rather than of tinfoil sheets. Callan's mode of insulating the wires of his coils was ingenious. He dragged the bare iron or copper wire through a hot bath of melted resin and beeswax, and this, when set, formed a highly insulating and sufficiently flexible varnish on the wire, which appears to have rendered silk or cotton covering unnecessary. The secondary circuits were wound on the plan, previously suggested by Poggendorff, of building up the secondary circuit of flat or vertical coils, so connected that no contiguous parts of the wire were at great differences of potential when the coil was in action.

Prof. Francis Lennon has given* the following details of the remains of Prof. Callan's apparatus, which are still preserved at Maynooth College as valuable relics. The large electromagnet constructed by Callan in 1836, consisting of a horse-shoe of iron, about 13ft. in length, and weighing 210lb., is still in existence (*see* Fig. 12), but it has been deprived in course of time of one of its circuits, so that it now remains as a simple and not a compound electromagnet. A somewhat smaller horse-shoe magnet, constructed by him on the same principle, with two wire coils, one thick and one thin, was the one presented

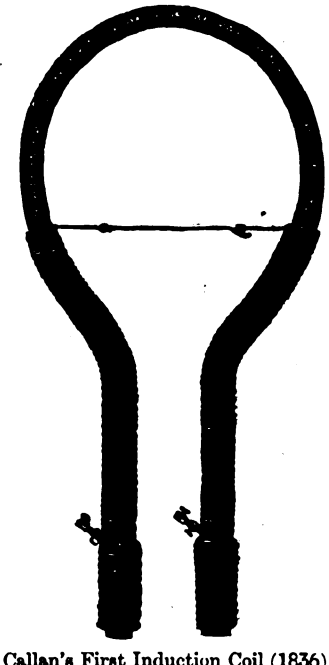

FIG. 12.—Dr. Callan's First Induction Coil (1836), with thick and thin wire Circuits.
Still preserved at Maynooth College.

to Mr. Sturgeon. In the Physical Laboratory at Maynooth also exists one of Callan's Electromagnetic "Repeaters," which was one of the first rapid contact breakers ever made.

§ 8. **Callan's Great Induction Coil.**—The most valuable relic is, however, the large induction coil, which may be regarded as the completion of Dr. Callan's labours. Although constructed 30 years ago, it is still one of the largest coils in existence. The representation of it in Fig. 13 is from a photograph recently made. The core is a cylindrical bundle of annealed iron wires 42in. in length, and 3·5in. in diameter. The thickness of each wire is $\frac{3}{16}$in. The primary coil is a copper wire, ·25in. in diameter, covered with cotton thread, and wound in three layers. For insulation the primary coil is covered with several layers of thin sheet gutta-percha, cemented by a paste, formed by dissolving gutta-percha, resin, and wax in boiling oil. The secondary coil is of *iron* wire ·01in. diameter, and consists of three separate coils or rings. The inner diameter of each coil or ring is 5·75in., and the outer diameter is 21in. Two of the rings are 3in. in thickness, and one is 4in. The rings are so arranged on the primary coil as to divide its entire length into four equal parts, the planes of the rings being perpendicular to the axis of the coil. In each ring both ends of the wire are

* See *Electrician*, March 6, 1891, Vol. XXVI., p. 554.

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left projecting, so that the separate coils can be joined in series or in parallel. The contact breaker is an automatic mercury break, worked from one extremity of the core. Two condensers, so arranged that they can be used together or separately, serve to reduce the spark at the break. With six cells of the Maynooth or cast iron battery, sparks 15in. long in air can be still obtained, the rings or secondary coils being joined in series. Prof. Gerald Molloy states* that the construction of this coil was commenced by Dr. Callan some years before his death, which occurred in January, 1864, and that it was then left in an unfinished condition. It was probably his intention to add more secondary coils to it. It remained one of the most powerful coils down to the time of the construction of Mr. Apps' large coils for the Polytechnic and for Mr. Spottiswoode. A long Paper by Dr. Callan on the induction apparatus, describing his latest researches, is printed in the *Philosophical Magazine* for 1857, Vol. XIV., 4th series, p. 323. This Paper is full of valuable suggestions and facts.

A description of the large induction coil, and experiments with it, will be found in the *Philosophical Magazine* for June, 1863 (Vol. XXV., Series 5, p. 413). Dr. Callan says that about three years and a-half before the date of writing he made an induction coil of considerable power. The secondary coil was of iron wire, No. 34 gauge, and consisted of three parts, two of which were each about two and a-half inches, and the third three inches long. The entire length of the secondary coil was about eight inches, and it contained 150,000ft. of secondary wire. He used thin sheet gutta-percha in insulating

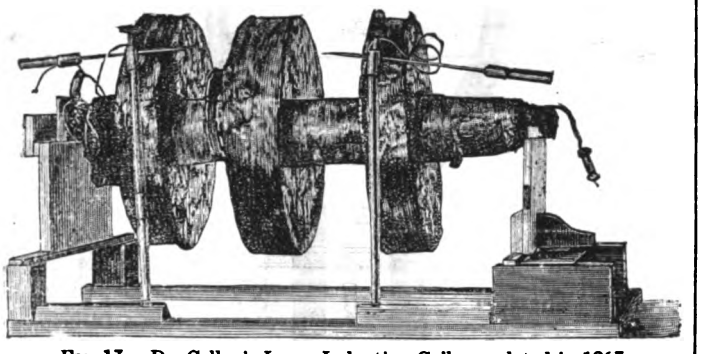

FIG. 13.—Dr. Callan's Large Induction Coil completed in 1863. Still preserved at Maynooth College.

the layers of wire. The primary coil was nearly three feet long, and the soft iron wire core three feet six inches long. This long primary coil was probably intended to be overlaid with more secondary wire, and as left at Dr. Callan's death the coil was incomplete. With three cells of the Maynooth battery this coil would give sparks 15in. in length.

Dr. Callan discovered that an increase in length in the spark is produced by connecting a large plate of any metal to the negative terminal of the coil, and that, in order to get the longest spark, the outer end of the secondary coil should be positive, and the inner end the negative. He states (see *Philosophical Magazine*, June, 1863) that when a pointed wire is connected with the positive end of the secondary a plate connected with the negative end lengthens the spark considerably, but when the point is connected to the negative end and the plate to the positive one the sparks are much shorter. Sparks 15in. long, when the first arrangement is made, are reduced to 11in. with the second. Sparks did not pass at all between positive plate and negative point until the plate was brought within eight and a-half inches from the point.

A ball, three inches in diameter, connected to the positive terminal shortens the spark as much as a 12-in. plate. He noted also that sparks from a positive point to a negative plate never went to the circumference of the plate, and scarcely ever struck the plate at a greater distance from the centre than three inches. But sparks between a negative point and positive plate always went to the circumference until the plate was brought to within two and a-half or three inches of the point; even when a rectangular plate 20in. by 28in. was used as the positive terminal the sparks flew to the edge of the plate.

§ 9. **C. G. Page's Researches in Electro-Magnetism.**—Very nearly at the same time that Prof. Callan, of Maynooth, was assiduously engaged in England in experimental inquiries on the induction coil, Dr. C. G. Page, at Salem and at Washington, in the United States, prosecuted with the greatest zeal and ingenuity similar researches on the other side of the Atlantic. Reference has already been made to his experiments with the ribbon coils of Henry, and which are described in *Silliman's American Journal of Science*, Vol. XXXI., for 1837, in a Paper dated Salem, May 11th, 1836, and entitled "Method of Increasing Shocks, and Experiments with Prof. Henry's Apparatus for obtaining Sparks and Shocks from the Calorimeter." In a second Paper, dated April 24, 1837, Page describes the construction of a large auto-induction ribbon coil, such as has already been described in § 2, which he now calls a "Dynamic Multiplier." This last coil consisted of a single ribbon of copper, 320ft. in length and one inch in width, wound into a flat spiral, the successive turns being insulated with strips of varnished cotton cloth. It had ten mercury cups soldered to the strip at various distances. With this apparatus he repeated all his former experiments on a larger scale. At this stage Page made an important contribution to the subject by inventing various forms of self-acting contact breakers to interrupt the primary current. One of the first of these (made in 1837) was a copper spur, or star wheel, the points of which just dipped into mercury contained in a little gutter or excavation in the base board which supported the wheel. He made this self-acting by placing a horse-shoe magnet so that its poles lay on opposite sides of the wheel, as in the experiment known as Barlow's revolving spur wheel. The electro-magnetic action of

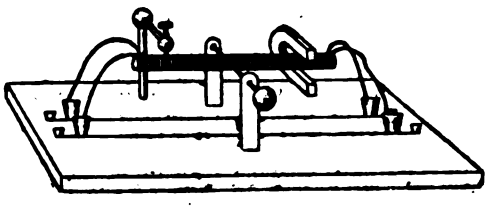

FIG. 14.—Page's Automatic Contact Breaker.

the radial current in the wheel on the fixed magnetic field caused rapid rotation of the copper spur wheel, and, hence, interruption of the current, as the tips of the stellate projections of the wheel passed into and out of the mercury. He found this arrangement to answer well for interrupting a current when powerful currents were used. Such an arrangement, however, failed with feebler currents, and he accordingly devised a rocking magnet interrupter, which he describes in this same Paper, published in 1837, and which was afterwards reproduced almost identically by Golding Bird as his own invention in 1838 (*see* Golding Bird, *Phil. Mag.*, Vol. XII., 1838). Page's contact breaker and Bird's reproduction of it consisted of a small electro-magnet (*see* Fig. 14) made of a piece of soft iron wire, one-eighth of an inch in diameter and three inches long, wound over in opposite ways with two separate insulated wires, the ends of one coil projecting at one end, and the ends of the second coil at the other. This small electro-magnet was balanced beam fashion on pivots, and so arranged that the projecting ends of the wires wound on it could dip in pairs of mercury cups at the two ends of the supporting board, according as the beam was tilted one way or the other. A permanent horse-shoe magnet was fixed so that one end of the beam electro-magnet could play between the poles. The mercury cups on the board were connected together, as shown in the figure. If a battery and coil were connected in series with one pair of mercury cups at one end of the board, it is obvious that matters could be so arranged that the reversals of polarity of the beam magnet as it was caused to tip its connections backwards and forwards into one or other set of cups, could not only maintain the rocking motion, but also interrupt the circuit of the coil. In the following year, 1838, Page had

* See *Electrician*, February 13, 1891, Vol. XXVI., p. 465.

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completed new and more perfect induction coils, consisting of two separate circuits, a thick wire primary, and a thin wire secondary, and he describes these coils in a very able Paper, published in June, 1838, in *Silliman's American Journal of Science*, Vol. XXXIV., July, 1838, p. 364.

He calls iron cores wound over with two separate circuits "compound electro-magnets," in the use of which phrase he followed Prof. Joseph Henry. These compound electro-magnets, or induction coils, were made with cores, consisting of bundles of fine soft iron wire, or strips of soft hoop iron. The cores were either straight or U-shaped. Dr. Page evidently arrived by independent investigations at a knowledge of the advantage obtained by using such divided iron cores, but whether before or after Backhoffner it is impossible to say. Page himself states that he used them before February, 1838, when Backhoffner first used them in England. These compound magnets were, however, induction coils of the form employed by Callan, and by their use Page obtained visible sparks from the secondary circuits, as well as very severe shocks, and produced secondary sparks by the help even of a primary current derived merely from one or two thermo-electric couples. In this same Paper, Page describes a remarkably interesting and ingenious induction coil which he called a "magneto-electric multiplier." He arrived by experiment at the conclusion that when an armature of soft iron was applied to one of his U-shaped compound magnets, the induction, as we now call it, through the secondary circuit for a given current strength in the primary, was much greater than when the armature was not present. Also

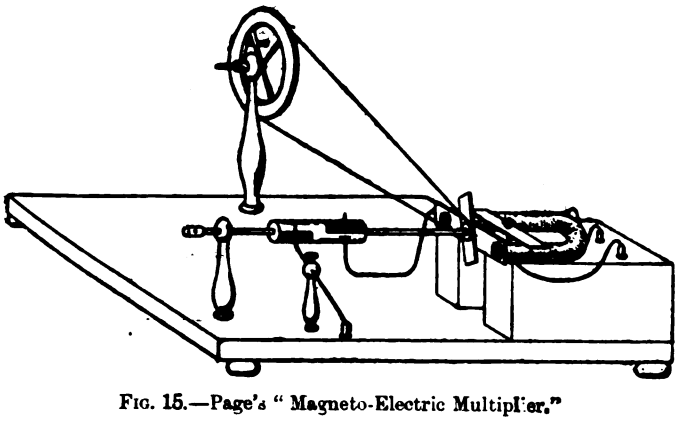

FIG. 15.—Page's "Magneto-Electric Multiplier."

that the depolarising power of the magnet was much greater when the armature was removed, so as to break the magnetic circuit. Hence it occurred to him that if he could first of all make his iron core a closed magnetic circuit *before* starting the primary current, and then break the primary circuit and open the magnetic circuit by detaching the armature directly afterwards, the combination of these two actions would put in and take out of the secondary circuit many more lines of force in the same time, and hence produce a greater electromotive force in the secondary circuit than if the primary circuit of a straight coil were simply opened and closed. This reasoning shows that at this date Page had acquired a great grasp of the true principles of electro-magnetism. The apparatus with which he put his ideas to the test is shown in Fig. 15. It consisted of a horse-shoe shaped induction coil, or a U-shaped compound magnet, the core being made of 500 soft iron wires, 12 inches long, and bent into the shape of a U. The primary coil consisted of five layers of No. 16 copper wire, and the secondary of seven layers of No. 26 copper wire, both being well insulated. This horse-shoe magnet was fixed on a wood block, so that its poles projected horizontally, and a soft iron armature fixed to a spindle, so adjusted that it could revolve in front of the poles. This spindle also carried a cylindrical wooden piece, having brass strips on parts of its circumference, and which had contacts made against it by a couple of brass springs. This was the primary current contact-breaker. By shifting the angular position of this cylinder relatively to the armature, it was possible to break the primary circuit at an instant corresponding to any defined position of the soft iron armature. It was normally set so as to break the circuit of the primary current when the soft iron armature was just leaving the position in which it magnetically completed the iron circuit of the magnet. Hence the primary electric circuit and the magnetic circuit were opened, one immediately after the other. The result was a very considerably greater production of electromotive force in the secondary circuit. Page got brilliant sparks from the ends of the secondary circuit of this coil, and unbearably severe shocks. He was also able to get a small arc when carbon points were used as terminals for the secondary, and he found the tension at the ends of the secondary was great enough to enable him to charge a Leyden jar. The same Paper which contains the description of this "electro-magnetic multiplier" also contains some very clear remarks on the use of divided iron cores, and on the magnetism of soft iron. Page employed sometimes cores made of very soft hoop iron, wrapped together, in making his compound magnets or induction coils. He knew very well that soft iron is capable of retaining a considerable amount of magnetism, provided it is not shaken or twisted. He illustrates this by an experiment in which a very soft iron wire was magnetised by being drawn once across the poles of a permanent magnet. It contains a considerable amount of magnetism if handled gently, and will lift up another piece of soft iron wire equal to itself in weight. If, however, it is given a flip with the finger and thumb, it immediately loses nearly all its magnetism. Page also was aware of the depolarising effect which a number of magnetic filaments, such as magnetised soft

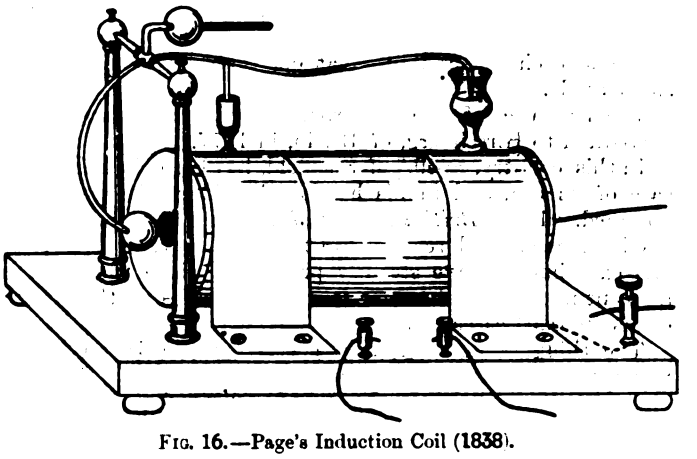

FIG. 16.—Page's Induction Coil (1838).

iron wires, exert on one another when bound into a bundle with similar poles adjacent. On this account, he says, a bundle of fine steel wires will act almost as well as a bundle of fine soft iron wires when used as a core for an induction coil. Page proceeded still more to improve the coil, and in *Silliman's American Journal of Science*, Vol. XXXV., 1839, he communicates another Paper, dated from Washington, Nov. 13, 1838, in which he describes a large induction coil closely resembling modern models. This last coil had a straight core consisting of a bundle of soft iron wires, and the coil wires were wound on a bobbin, having wooden cheeks. The primary wire was a thick copper wire, and the secondary a very fine copper wire. This coil was provided with an automatic hammer break which broke and made a mercury contact (*see* Fig. 16). The hammer head was a ball of soft iron, which was operated by the magnetism of the core. The hammer head was prevented from sticking to the end of the core when attached by the interposition of a small piece of brass. The vibrations of the hammer worked a mercury cup break placed on the coil and which interrupted the primary currents. Page noted the fact that the deflagration of the mercury at the point of break had the effect of prolonging the contact because the primary current continued to flow in the mercurial vapour. Hence, it occurred to him to prevent this by putting oil or alcohol on the top of the mercury to quench the spark and increase the suddenness of the break. This device was revived many years after by other inventors, particularly by Foucault, but it seems first to have been used by Page, in 1838.

(To be continued.)

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THE ELECTRO-MAGNET IN EYE-SURGERY.

BY SILVANUS P. THOMPSON, D.SC., F.R.S.; AND J. TATHAM THOMPSON, M.B., C.M.

For many years past, ophthalmic surgeons have used both steel magnets and electro-magnets. Indeed, the use of the loadstone has been known for two centuries,* for the purpose of extracting from the eyeball chips of iron which have by accident lodged therein, as frequently happens in engineering workshops to fitters and metal turners. Later, in 1745, Dr. Milnes, in his "Observations of Medicine and Surgery," describes how he applied a loadstone to remove a piece of iron from the iris. Probably this was not strictly the case, as he says "immediately it jumped out." It is more likely that he meant that the fragment of iron was embedded in the cornea in front of the iris. According to Hirschberg,† Dr. Meyer, of Minden, was, in 1842, the first to use a magnet in extracting fragments of metal from the actual interior of the eyeball.

In the middle of this century cases of successful removal were recorded by Critchett,‡ Dixon, White, Cooper, and others. There seems to have been little advance until 1874, when Dr. McKeown, of Belfast, recorded in the *British Medical Journal* several successful cases treated by means of a permanent steel magnet tapered at each end to facilitate its introduction.

In 1880, Gruening, of New York, employed a permanent steel magnet composed of a number of "cylinders" (*sic*), united at each end and fitted at one extremity with a needle-shaped pole.

The first use of the electro-magnet in this connection is accredited to Hirschberg, of Berlin, in 1877.

In this country, Snell,‖ of Sheffield, has been the chief advocate of its use, and in his hands splendid results have been obtained. In the *British Medical Journal* for 1881 he describes his instrument and records the results of several operations. His experiments have steadily progressed since then, and in a recent number of the same journal he brings up the number of his recorded cases to 77.

The thing needed for this special service is an electro-magnet which can be fitted with polar appliances of various elongated forms which can be introduced into the wound in the eyeball to a sufficient distance to enable the particle of iron to be attracted and withdrawn. It is necessary at the same time that the electro-magnet should not be too heavy to be conveniently held in the hand of the operating surgeon, and that it should be capable of being excited with current from a battery of moderate size, such as an oculist might be expected to be able to manage and maintain without having to call in a skilled electrician at every occasion of its use. It is obvious that, other things being equal, a magnet of considerable projective power is desirable; hence one with a long core, or with an iron expansion at the posterior end of its core, is preferable to a short one. Possibly in some cases the placing of a mass of iron behind the patient's head during the operation might aid the electro-magnet to project its magnetic field to the desired depth. Various forms of magnets have been devised by various experimenters.

Snell's instrument, which may be quoted as the typical form commonly used by ophthalmic surgeons in this country, consists of a soft iron core surrounded by a coil of insulated copper wire enclosed in an ebonite case. At the one extremity are the terminals for the battery connections, and at the other the soft iron core is tapped to receive the variously shaped and sized needle poles. He recommends the use of a single quart bichromate cell to generate the current.

Hirschberg's instrument consists of a hollow cylindrical core with two curved pointed poles of different thickness for external and internal use.

Bradford, of Boston, devised an instrument almost identical with Snell's, and simultaneously with the latter. It is, however, a much heavier and more powerful agent.

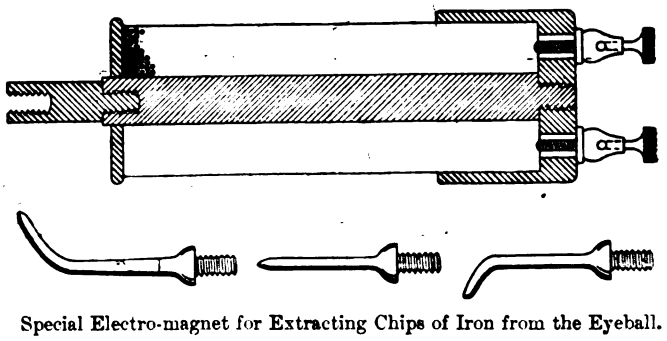
McHardy, of King's College Hospital, used a very similar instrument, but of much reduced size and weight.

The latest form (see Figure below) is that brought out by Tatham Thompson, of Cardiff, and is a further modification of Snell's instrument, but for the same weight and bulk, additional power is claimed, as the magnetic circuit is perfected by means of a collar of iron continuous with the core projecting forwards over the insulated coil towards the manipulative pole piece.

The core is tapped at its extremity to receive the differently shaped poles or an intermediate polar extension where deeper probing is required. The battery used with this consists of one or more quart bichromate "dip" cells. This instrument is shown in the illustration in its actual size, and its weight is only about five ounces.

The most frequent use of the instrument is in removing fragments of steel or iron from the surface or embedded in the coats of the eye, and by its use much disturbance and laceration of the delicate structures is avoided, which the older methods of cutting out or withdrawing by means of forceps, spuds, or curettes, too often involved. Its most valued properties are, however, best demonstrated where it is used for the removal of foreign bodies which have penetrated the walls of the eye. It is not too much to say that in many cases it has been the only possible means of preserving sight.*

In the first place, it is of diagnostic value, for where a fragment, for instance, has perforated the cornea or anterior transparent part of the eye, it can often be proved whether it is steel or iron by observing whether it is acted on by the close approach of the instrument. If no movement is observed, and no peculiar sensation of dragging pain felt by the patient



Special Electro-magnet for Extracting Chips of Iron from the Eyeball.

on the approach of the magnet, it may be due either to its not being a magnetisable metal or to its being gripped by the tissues, or encysted with inflammatory material thrown out by its irritating presence. If in this case a very lightly suspended needle be magnetised and held close to the eye, it may sometimes be found to dip towards the foreign body. If it should chance to be a steel fragment, this effect is greatly increased by holding the electro-magnet close to the eye for a time, so as to magnetise the offending particle.

Further still, the instrument is at times of immense use in moving the fragment from one part of the eye where it is inaccessible, and dropping it in a more favourable position for subsequent removal. For instance, suppose the fragment of steel or iron has penetrated the cornea and lodged in the crystalline lens, it has happened in several cases that by applying the electro-magnet to the cornea the metal has been attracted forward through the lens substance, across the aqueous humour contained in the outer chamber of the eye, and then dropped by opening the circuit on to the floor of the outer chamber; then a small opening being made at the most dependent part, the pole of the instrument introduced there, and the fragment readily removed.

In at least one recorded case a sharp-pointed fragment, which had penetrated deep into the lens, has been seen to force its way

* Fabricius Hildanus, *Opera observationum et curationum*, Frankfort, 1646. Of this rare work we have not seen a copy.

† Hirschberg, *Der Elektro-magnet in der Heilkunde*, Leipzig, 1885.

‡ The *Lancet*, April, 1854, p. 358.

‖ Snell, "The Electro-magnet and its Employment in Ophthalmic Surgery." London: Churchill and Co., 1883.

* In addition to references previously given, *see* Mellinger, *Ueber die Magnet Extractionen an der Basler ophtalmologischen Klinik* (Inaug. Dissert.), Basel, 1887.

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forward through the lens substance and lens capsule, through the iris, and actually be drawn through the cornea, and so removed completely without involving any cutting operation whatever.

It is, however, in those cases where the foreign body has penetrated the posterior or vitreous chamber of the eye that the wonderful results obtained by the electro-magnet are best seen. Where only the outer chamber or the lens is the seat of the mischief, other means may possibly succeed; but when a fragment has penetrated the vitreous chamber, we require an instrument not to go blindly searching round, disturbing the delicate structures and risking the escape of the semifluid contents, but one which will attract to itself the offending particle, and this is where the instrument which we are considering reaches its highest achievements.

Many successful cases have been recorded by Snell, Hirschberg, Lloyd Owen, McHardy, and others, of fragments of steel thus removed from eyes which otherwise must have inevitably been lost.

The most serious and desperate cases of all are where the metal has actually traversed the inner chamber of the eye and become embedded in the delicate retina and choroid lining the posterior wall. So far as can be ascertained, only three successful cases of removal from this position have been recorded. The first by Galezowski in 1882, where a fragment of iron had passed through cornea, iris, and lens, and was lodged in the retina. Its position was noted by means of the ophthalmoscope, an instrument employed by ophthalmologists for examining the interior of the eye. An incision was made in the sclerotic or white coat of the eye over the situation, and the fragment removed by means of the electro-magnet. The second, recorded by Hirschberg in 1888. The third by Tatham Thompson, of Cardiff, in 1890. Some detailed account of this will illustrate the method of the procedure.

The patient was a blacksmith employed at one of the South Wales collieries, and on December 8th, whilst "stamping" a new "pick," was struck on the left eye by a fragment of the new tool. The fragment struck him on the "sclerotic" or white of the eye," about a quarter of an inch from the margin of the cornea. He felt little pain at the time, but two days later dull pain supervened, and considerable irritation and dimness of vision, not only in the injured but in the sound eye.

He was sent to the Cardiff Infirmary on December 10th. When examined there, a small wound was found at the point where the fragment had entered on the inner side, and on ophthalmoscopic examination, the piece of steel could be seen embedded in the retina at the upper and outer part. The track which it had made in traversing the vitreous chamber could also be distinguished by slight opacities in the humour. The uninjured eye showed distinct signs of sympathetic irritation. The next day the patient was put under the influence of ether, the wound of entrance slightly enlarged to allow the introduction of the pole of the electromagnet. This was passed across the vitreous chamber in as nearly as could be calculated the direction originally taken by the fragment. On withdrawing the first time nothing resulted, but at the second attempt the piece of steel came readily through the wound "in tow" of the pole. Only a very small bead of vitreous humour escaped, and the eye was dressed antiseptically and bandaged. At the end of 24 hours he could count fingers at 4ft. distance, was quite free from pain and dread of light, and the dimness of the other eye had largely disappeared. The wound healed in three days, and the sight steadily improved, till on December 30th he could read moderately sized print. Examined by means of the ophthalmoscope, the scar formed in the retina at the point where the fragment had lodged could be distinctly made out, as well as some patches of hæmorrhage caused either by injury from impact of the fragment or by injury of retinal vessels at the time of its removal.

On January 13, 1891, he could read small print; his central vision, in fact, was as good as ever, but his "field of vision" was limited slightly below—the limitation corresponding to the portion of retina injured by the foreign body.

The electro-magnet has been used also to some extent in general surgery for the removal of needles from the soft tissues of the body or limbs.

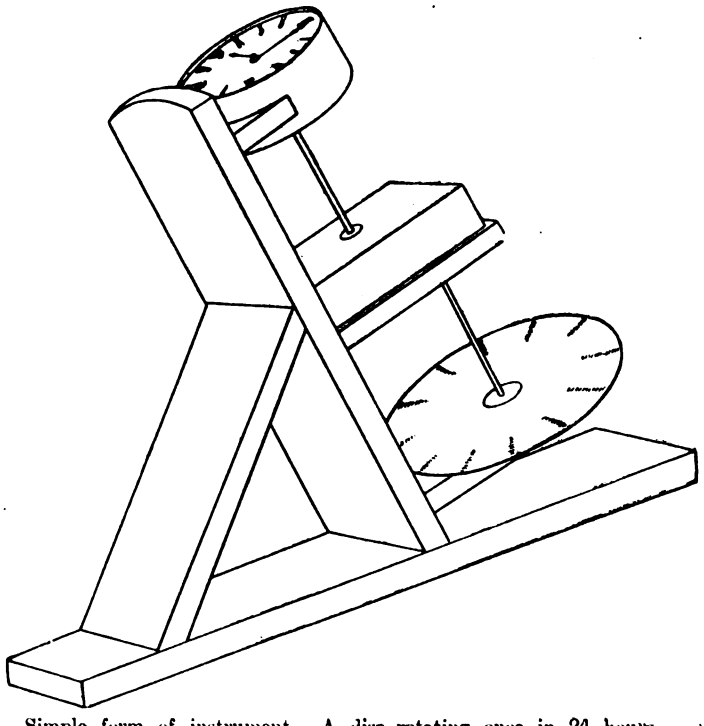
PHYSICAL SOCIETY.

At the meeting of this Society on June 12th, Prof. O. Lodge, F.R.S., exhibited and described

'A Clock for Pointing out the Direction of the Earth's Orbital Motion in the Ether."

After observing that his attention was directed to this matter by some problems relating to aberration, he said that a point on the earth's surface was always moving to the west, in virtue of the diurnal rotation of the earth, at a speed of 700 miles an hour. At the same time it was being carried in the plane of the ecliptic in a direction at right angles to the sun at a speed of 19 miles a second, while the whole solar system is supposed to be moving towards a point in the constellation of Hercules at a speed of about five miles a second. This combination of motions was not easy to conceive.

An apparatus for pointing out this direction was, therefore, convenient when dealing with problems requiring a knowledge of the motion of a point through the ether. A simple and early form is shown in the figure, and in the more elaborate form one spindle, representing the earth's polar axis, and another the axis of the ecliptic, were inclined at an angle of 23½deg., and coupled by a Hooke's joint. The latter axis was capable of rotating round the former. At its upper end the ecliptic axis carried a tube and a



Simple form of instrument. A disc rotating once in 24 hours graduated to show the dates throughout the year. On any given date the radius corresponding to that date points in the required direction.

pointer, both being perpendicular to the axis and to each other. The clock keeping solar time rotated both axes, and when properly set the tube pointed in the direction of the sun, and the pointer, therefore, indicated the direction of the earth's orbital motion.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

FRIDAY, June 26th.

PHYSICAL SOCIETY OF LONDON.

5 p.m. Ordinary Meeting. Papers to be read: (1) "The Construction of Non-Inductive Resistances." By Prof. W. E. Ayrton and T. Mather. (2) "The Influence o Surface-Loading on the Flexure of Beams." By C. A Carus-Wilson. (3) "On Pocket Electrometers." By C. V. Boys. (4) "On Electrification due to the Contact of Gases with Liquids." By J. Enright.

ROYAL INSTITUTION.

9 p.m. Faraday Commemoration Lecture. By Prof. Dewar, F.R.S

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

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THE EDISON LAMP PATENTS.

Once more, and probably for the last time, the EDISON lamp patent has appeared in the law courts; not here, fortunately, but in the United States. The case is of a protean nature, depending as it does on the country in which it is tried, the patent laws of that country, and the parties to the action. On no two occasions, during the many independent trials which have been held, have the same points been urged, or the same standpoint adopted. The WOODHOUSE and RAWSON case of 1886, which might have settled the question, as far as the English interests are concerned, was bungled in a most unsatisfactory manner; unsatisfactory to the plaintiffs since they had to fight again in 1888, and unsatisfactory to the defendants who lost their case and their lamp-making business. EDISON *v.* WOODHOUSE and RAWSON degenerated into an uninteresting dispute about the definition of a filament, a definition which was dismissed as being quite unimportant in EDISON *v.* HOLLAND, but which was reinstated in the appeal and reversed the judgment of Mr. Justice KAY. In EDISON *v.* HOLLAND, the EDISON and SWAN interests were united, and arguments were based upon such details of the work of those two inventors as were calculated to support the monopoly.

While united against a common opponent in this country, a law-suit was being carried on in Germany at the same time, between the EDISON and the SWAN Companies, and the evidence on some points could hardly be recognised as being based upon the same facts as those which were brought forward in the English law courts. The result denied to EDISON the rights of exclusive manufacture of glow lamps, and confined those rights to lamps of the kind which he described. The present trial in the Southern District

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Circuit Court of New York seems to follow the lines of EDISON *v.* HOLLAND, rather than the SAWYER-MANN and other American suits. No originality is to be looked for in the judgment, for almost every possible decision has been given already by some judge or other, and it is difficult to feel much interest in the outcome of the controversy.

The present case has opened with a very elaborate speech, which attempts to impart to the judge a schoolboy's knowledge of elementary electricity, and an elaborate *resumé* of the history of the invention of the modern glow lamp. A superficial glance at this speech conveys the idea that this, like the other law-suits, is founded upon an accurate recital of the events which led to the invention. As a matter of fact, a number of interesting, and, for the most part, isolated bits of history are dug up, and after a little trimming and preparation, depending on the purpose for which they are required, they are presented by counsel or witness to the judge and to the public. But when we come to watch more closely, we soon find that neither judge nor counsel want to bother themselves with mere history of scientific work, but are really concerned, as of course it is their business to be, with the chronology of the patents. From their point of view this is natural, since, on the one hand, the patenting of an invention is the only proof of proprietorship that the legal mind is concerned with, and the history of an invention, prior to its patenting, is only to be considered in cases of prior publication. Although the patent is supposed to be granted only to the first and true inventor, the private work in a laboratory and the exhibition of the results to a few visitors is not, legally, of any account. By such work the result, and, indeed, a far more developed and useful result, may be achieved, but the author is not entitled to be called the first and true inventor unless he pays a fee to the State, or else throws open the result of his labour to the public.

As a matter of history it is well known that SWAN hit on the use of carbon, made lamps with carbon filaments, and LANE-FOX recognised the economical importance of high resistance before EDISON did. Had EDISON worked with as little ostentation as SWAN, there would have been a difficulty in arriving at this conclusion, but all the world was ringing with the marvellous platinum lamp which was the immediate cause of the panic among the shareholders of gas companies. LANE-FOX had given platinum a fair trial, and knew its weak points; SWAN had made patient experiments with carbon, and was just arriving at success, being convinced that carbon was the right material to use, while the daily papers were full of EDISON's wonderful "subdivision" of the electric light. EDISON applied for ten patents for electrical inventions in this country during the years 1878 and 1879, six of these relating to electric light. SWAN applied for no electrical patents until 1880, though in 1879 he patented several inventions in connection with the equally important discovery of the gelatine photographic dry plate. We should not be surprised if EDISON wins again, since it is probable that his claims are justified legally, on account of the large number of patents which he has taken out. It would be strange if none of them could be found to cover the more important parts of the lamps with which he was experimenting at that time. But this has little or nothing to do with the credit of priority which is esteemed highly by all inventors, and too highly by some of them. It is an historical fact, which bears slightly, if at all, on the legal question, that EDISON's much be-puffed platinum lamp, which proved to be quite worthless, gave rise to a panic in the shares of gas companies in January, 1879. At this time, SWAN was already on the road to success with horse-shoe filaments of carbon, and in the following month he exhibited them at the Literary and Philosophical Institute, at Newcastle. But SWAN did not venture to patent his imperfect attempts; he was fully alive to their defects, and waited for something better. Had he filed a clever specification for these horse-shoe filaments he would undoubtedly have been master of the situation. In October 8, he received a letter from a friend who, alluding to EDISON's experiments, said "he has trodden so closely on our ground that, if he has patented his process, I am afraid he has anticipated you entirely." And it has been held that EDISON did so anticipate SWAN. But was the anticipation a patent or an invention? It was a mere patent. It described a closely coiled filament of a putty of tar, and no lamp has ever been shown which was made under that patent, except for purposes of litigation; and the amount of combined talent which was expended by some of our best men in striving to make, according to that patent, something which they could swear was a lamp, would, if expended on improving the glow lamp in 1879, have assisted its development to a very marked degree.

The principle laid down by Lord ELDON, that a patent is a bargain between the public (represented by the Crown) and the patentee is generally recognised, and one of the conditions of the bargain is that the patentee should clearly describe the best method known to him of performing the invention. "The best method" premises a good method, but we cannot believe that EDISON, in his most sanguine mood, could ever have thought that the tar-putty filament was a practicable one. It was a step, as was the paper horse-shoe of SWAN, which was a superior affair, and which, with but slight modification, is still to be seen in the MAXIM lamp. We know of no trace of tar-putty filaments to-day, or of anything which can be said to be a development of them. Nor is the bamboo lamp, that remarkable outcome of the patient and untiring experimenting for which EDISON is so justly famed, to be found in ordinary use. Our glow lamp is the direct outcome of SWAN's further work, which, when really promising success, and fit to publish, he lost no time in protecting, as the patent record of 1880 shows.

As for the "bargain between the patentee and the public," and his "clear description," it is mere irony in the case of EDISON's patent. And even to-day the lamp patents disclose as little as possible; the useful and important points which go to make a good lamp are jealously guarded trade secrets, in direct opposition to the principle of patents.

ELECTRIC AND MAGNETIC THEORIES.

BY JOHN T. SPRAGUE.

(Concluded from page 190.)

§ 17. In considering Figs. 12—14, p. 132, we need a starting-point, which Prof. Thompson fails to supply. Do these lines and planes originate at the wire, and spread out into space to unknown distances? That is the common-sense view, and it is that of my theory, for these lines are merely the dotted lines I of static stress, and M of magnetic stress of my Fig. 2, reproduced on p. 161. But, as I understand the new theory, they must be constructed from outer space, and flow in towards the wire. So this brings us back to the old question, what is it in the wire which causes it to draw energy towards it which has started away on a radiant course? I take it we shall all agree that an effect cannot be its own cause. Therefore, radiant energy cannot itself construct these equipotential paths by which it is to be carried back towards the wire. It can construct them, by an action gradually extending from the wire, as a foundation, through layer after layer of the surrounding matter. But even if we admit the transfer from P to Q, Fig. 14, we have not yet got the energy to P, along, say, that 1,000 miles of space from the source. How often does it "swirl" on the road?

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§ 18. Prof. Thompson, on p. 160, Figs. 15 and 16, lays out some imaginary difficulty in my way, and "puts it forward as a cardinal point in the controversy." I accept it, and claim it as a new proof of my theory. Fig. 16 appears to be a diagram of a common experiment, a great favourite of young gutter philosophers, who put a little stick across the flowing water and produce the small whirlpools shown. Fig. 15 shows an electric current as observed under similar circumstances. I must thank Dr. Lodge for this illustration, and will ask his permission to use it when I want to show how my theory has been proved correct by him, and am obliged to Prof. Thompson for specially directing my notice to it. Why, those observed lines are actually my polar chains of current? and they are very neatly worked out again in Fig. 17. I may as well remark that the term "end thrust" is not my term at all, and that nowhere have I suggested that what we call "electric current" involves a motion of translation; on the contrary, I have always maintained that the motion is one of rotation of molecules within a line, and not one of translation. Therefore it does not involve the production of the "swirling eddies," shown in Fig. 16 and in the gutters; it does involve "stream lines symmetrical in front of and behind the obstacle," as in Figs. 15 and 17. I do not know that we are limited to Dr. Lodge's "three possible alternatives," and I do not see that No. 3 of these, "the propelling force acts at every point of the path," is in any way inconsistent with my theory, that it is by means of the internal forces of all the molecules forming the circuit that electrical phenomena are produced. The considerations in § 20 would have more weight if these "stream lines" were really continuously existent during current; but this they cannot be. They are each set up, on my theory, by energy impressed on them at the source, by chemical actions among infinitesimally small particles of matter, or by each rotation in a field of force; each such impulse is complete in itself, not a continuous pressure. The apparent continuity results from the rapid succession of impulses; therefore, there is no difficulty in conceiving the greater rapidity of motion where there is less matter to spread the action over.

§ 19. Having dealt with Prof. Thompson's own arguments and shown that either they do not apply or fail in essentials to meet the problem, I wish I could leave unnoticed the two last columns in which he deals with my articles. I cannot do so, or I should be told I was silenced. But I will ask any impartial person to say whether my arguments are even touched. Prof. Thompson deals some "swashing blows," but they fall on a thing of shreds and patches, a scarecrow of his own device, in which I can hardly trace even a bad caricature likeness to my production.

My Fig. 2, reproduced to demolish, is a mere outline index to my arguments, in no way offered as itself explanatory; the long current arrow is merely the conventional symbol of electric current; the dotted lines, I, merely indicate static stresses actually existing from all parts to all parts of the circuit; the special forms of the arrows have no occult meaning calling for any "Good gracious, what are we coming to?" I am afraid I might borrow those words as to the criticism on my poor four energy arrows and their offsets, for this at least is certain, they represent the fact that the energy is simultaneously distributed in both directions along the circuit, irrespective of any theory as to the nature of current. If Prof. Thompson cannot understand the voltameter, I am in the same condition as to his criticism. Does he suggest that current does not traverse voltameters just as it does a battery, only expending energy instead of gaining it, which is just what my figure shows?

He retorts my question as to how the energy knows where it is wanted, but his question has no meaning. I have shown the limiting paths for the energy, and the calls upon it (like toll bars) compelling it to pay for its carriage as it goes. He merely says it goes to those places, without giving any reason why it should, or any mode by which it is compelled to. I am not going to be led off into Hertz experiments just now. I hope, when I have time, to write some Papers on "a common-sense study of the Hertz experiments;" just now they would simply introduce confusion.

§ 20. But I am willing to give a problem. The one special difference between Hertz and other experimenters on induction, is the use he has made of "reflection" from surfaces, and the generation by its aid of "nodal" points; this reflection is another form of what has been studied under the name of screens and shielding. Now will Prof. Thompson construct a screen or reflection surrounding the fine wire in his Fig. 9 and secure total reflector of the energy streams (an imaginary one will do, and is more easily made perfect by the formula "let us conceive")? Will he tell us that now energy is shut off from outside, his fine wire will no longer get heated? Will he deny that the current and energy will go on unaffected, save by any change which may be produced in the resistance of the wire as due to heat?

§ 21. I suppose Prof. Thompson would call his comments upon my hydraulic analogy criticism. I do not. Would he write a review of that collection of truths, Æsop's fables, and begin with, "Does this author really expect us to accept all this nonsense as fact?—if so, he should have obtained sworn copies of the shorthand writer's notes, or, better still, a phonogram of the asserted conversations"? Would that be a bit more absurd and unfair than his, "what trifling all this is. Are the copper conductors elastic? Do they swell up or contract in order to produce the effects of surface charge, magnetic stresses, and the like?" The question is whether my analogy, treated with reasonable intelligence, does convey a clear meaning; analogy is not identity; my analogy was meant to show a mechanical process, absorbing and storing energy, and bringing about results, in masses of matter, resembling those produced electrically among the molecules of matter. Had it not been a thoroughly good one, and one which cannot be answered, it would have been answered instead of being ridiculed without reason. As to all the rest, I carefully separated stress and flux, variable periods and steady currents, the conductive and dielectric functions of matter, and directed consideration to each separately. Prof. Thompson pitchforks them all together, and then complains that any particular scrap he picks out does not meet the whole case. Will he or someone now give us an explanation of what the new theory really does mean?

THE FRANKFORT EXHIBITION.

The principal exhibitors have now made considerable progress with their exhibits, and in the Machine Hall, which was, of course, the most backward, all the firms, with the exception of Siemens and Halske, and the Lahmeyer Company of Frankfort, have the greater number of their machines running. Schuckert and Co. are setting up a fourth 100 H.P. steam engine; they have already three in full use, including their largest, which gives about 300 H.P., and runs quietly and smoothly at about 145 revolutions per minute, coupled directly to a large ring machine The firm has also a rotary current dynamo, which is to drive a similar motor, both in the Machine Hall, but these are not at work yet; a rotary current motor is, however, running in the hall for the distribution of electricity. Schuckert and Co. do not recognise the term "rotary current machine," but prefer the name of alternating machine with different phases. A model tramway erected by this firm is now in operation, running between the Electrical Distribution Hall and the Marine Exhibition on the Main, a distance of about 150 yards. The system resembles the Lineff very closely.

A Berlin firm, Naglo Brothers, occupy the space next to the Schuckert Company; they have been in full work for some time, but their exhibits, though very well arranged, are not amongst the most extensive. They have an 80 H.P. steam engine, to which is coupled direct an interior pole machine, and two dynamos are driven by belting by the same engine; the latter are drum armature shunt machines, and are provided with an automatic switch for putting either machine out of circuit in case of inequality of pressure. These dynamos supply current to 500 Swan glow lamps and 24 arc lamps. Adjacent to the last named firm, the Esslingen factory are showing an eight-pole dynamo for the five-wire system (480 volts × 124 amperes) running directly coupled to a 100 H.P. engine. This machine supplies current to a motor in the pumping house on

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the Main, the motor being of the interior-pole type, and of 50 H.P., as well as to arc and glow lamps on the five-wire mains.

The Thomson-Houston Company have one dynamo now at work in the Machine Hall, driven by a 30 H.P. gas engine, by a Munich company. Their machine seems to attract much attention from Germans, which, perhaps, is not entirely due to the brilliant coruscations at the brushes. Their latest electricity meter is also a centre of attraction. This Company have begun setting up their pumping-house installation, which lies well at the back of the Exhibition. They are just setting up a dynamo-motor, driven by the dynamo in the Machine Hall, actuated by pulsating currents; this will, in its turn, drive a pump, consisting of a piston and cylinder, in which coils are inserted; these, by means of the varying current, attract and repel the iron core of the piston alternately, giving about 300 strokes per minute.

Under a signboard marked "Woodhouse and Rawson," Messrs. Ruston and Proctor, of Lincoln, have a space allotted to them in the Machine Hall, next to the Thomson-Houston Company. A Kingdon alternator, belted to a 60 H.P. horizontal compound engine with automatic expansion and a "Porter" regulator, forms their chief exhibit. Messrs. Lahmeyer, of Frankfort, are busily at work erecting a high-pressure central station, and this bids fair to be one of the most interesting in the Machinery Hall. When this firm's exhibits are all *in situ*, they will include a high-pressure dynamo (660 volts × 110 amperes) driven by a 100 H.P. compound condensing engine, a similar but smaller dynamo driven by a Westinghouse engine, and a low-pressure exciter driven by a triple expansion 30 H.P. engine.

The exhibit of the Helios Company of Cologne is in full working order. Their great 2,000-volt 600 H.P. alternator has proved a great success, and forms the great centre-point of attraction in the hall. This machine lights up the dome of the hall with hundreds of glow lamps, besides supplying current for arc lamps and motors. The Helios Company are particularly well favoured in position; they have the very centre of the hall, and almost divide it into two parts, and their exhibit is visible from three sides.

Siemens and Halske, whose exhibit must have cost a considerable sum, have a good position at the extreme end of the hall. Fresh plant seems to arrive for them every day, and they are rapidly bringing their installation to completion. Their direct-current 330-kilowatt machine is already set up, but not in use. This machine, with the above load, is to run at 100 revolutions per minute, but if necessary the load may be increased to 500 kilowatts. It is the largest direct-current machine yet in Germany; the armature has an outside diameter of 9ft. 9in. It is an interior 10-pole machine. The great alternator of this firm is also ready. The outside diameter of the armature is about 15ft., while that of the ring on which the magnet coils revolve is nearly 12ft.

The importance to which the Schuckert, Helios, and Siemens firms, not to speak of many others, have given to the exhibits in the Machinery Hall, and the extensive way in which nearly all the firms here represented are exhibiting, make this part of the exhibition of the highest interest. It may be worth mentioning that the electrical and other apparatus in the exhibition, not including objects of art, &c., are insured for between two and three hundred thousand pounds, of which sum Siemens and Halske's exhibit represents over £38,000, and Schuckert and Co.'s £30,000.

ELECTRICAL INSTRUMENT MAKING.

II.—PIVOTTED GALVANOMETER.

Where greater delicacy and sensitiveness are required than can be obtained with the instrument described in the preceding article (*The Electrician*, June 5, 1891), and where portability is at the same time a necessity, the instrument now to be considered will be found useful. It belongs to the class in which the needle system turns horizontally on a single pivot.

The outer case, *a a* (Figs. 1 and 2), of the instrument is turned up out of boxwood, and is 4in. in diameter and 2in. deep outside. The inside recess has three different diameter measurements. The lowest part, having a diameter of 3in. and a depth

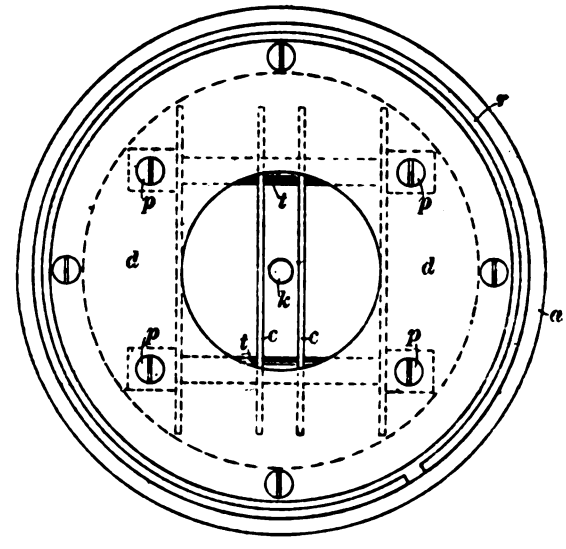

Fig. 1.—Pivotted Galvanometer. Plan.

of 1⅛in., receives the coils. On the bottom of the next section, which is 3½in. in diameter and $\frac{5}{16}$in. deep, the brass dial (*d*) of the instrument is fixed, while the top part of the recess (3¾in. diameter and $\frac{3}{16}$in. deep) contains the glass cover *g* and its fastening ring *r*.

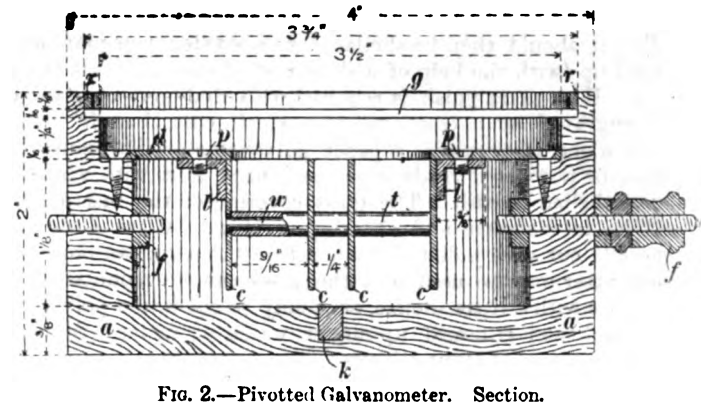

Fig. 2.—Pivotted Galvanometer. Section.

The bobbins upon which the coils are wound are constructed as follows:—*c c* are four brass cheeks, 2½in. × 1in. × $\frac{1}{32}$in., having holes large enough to take a No. 13 wire (about $\frac{1}{10}$in. diameter), drilled ½in. from each end, and equidistant from

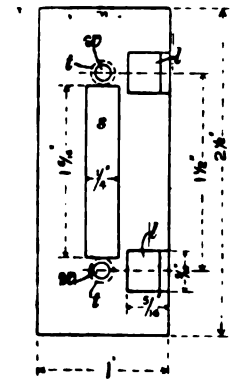

Fig. 3.—Pivotted Galvanometer. Details of Bobbins.

each side; between these holes are slots, *s* (Fig. 3), 1$\frac{5}{16}$in. long by ¼in. wide; *t t* are lengths of brass tube about $\frac{3}{16}$in. external diameter, and of metal sufficiently thin to allow of a straight piece of No. 13 S.W.G. wire being passed through them. The

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cheeks and the tubes (which serve as separating pieces) are slipped on to pieces of No. 13 brass wire, 1⅝in. long (shown at *w*, Fig. 2). The tubes separating the inner cheeks should be ¼in. long, and those between the inner and outer cheeks $\frac{9}{16}$in. The holes in the outer cheeks should be slightly countersunk on the outside, and the ends of the wires *w*, as soon as the cheeks and tubes are in position, should be riveted over and filed down flush with the surface of the cheeks; *l l* are lugs for fastening the bobbins to the dial *d*, by means of the countersunk screws *r*. The easiest way of making these lugs is to grip a piece of sheet brass in the vice, bend it sharp over, and hammer it about square. Finish it on the angle of the surface-plate, and then file up the back. If the brass is too hard to bend without cracking, make it red hot and drop it into water. The lugs should be soldered to the cheeks in the position shown with soft solder. The surfaces of the lug and cheek should be tinned and held together in position with a small pair of pliers over a Bunsen flame until the solder oozes out from between them. They should then be removed from the flame and cooled. The lugs should, of course, be fixed before the bobbins are put together. In making the cheeks they should be stuck together with shellac, so that they may be all drilled and filed up together. This will ensure of the bobbins being square and true when finished. The best way to make the slots is to drill a row of holes $\frac{3}{16}$in. in diameter, and $\frac{3}{16}$in. from centre to centre, drilling every alternate hole first and then the intermediate ones. The slots may be finished off with a small cold chisel and a file. The brass dial is 3½in. in diameter and $\frac{1}{16}$in. thick ($\frac{3}{32}$in. stuff); it has a circular opening in its centre about 1½in. in diameter. This opening is merely to pass the needle of the instrument through, and is shown circular instead of being simply a slot on account of the greater facility with which it may be thus made.

The dial *d* should be first roughly cut out of a piece of sheet brass and carefully flattened by hammering with a wooden mallet, it should then be shellaced to a wooden face-plate and turned up (with the help of a slide rest, if such a tool is available). If an extra finish is required, this dial may be silvered and engraved at a comparatively small cost, but if plain utility alone is required, a paper galvanometer dial must be drawn, or purchased ready made, and fixed to *d*, with white of egg or shellac varnish. The glass covering of the instrument is 3¾in. in diameter and about $\frac{1}{16}$in. thick. Glass discs are generally cut with a diamond on a turn-table, but an ordinary glass cutter may be used, and the glass can be mounted on a face-plate with a little shellac, or it may be cut into a polygonal form, and then trimmed up under water, or under a running tap, with a pair of stout scissors.

A brass ring, *r*, holds the glass in position. It is made of hard strip brass ⅜in. wide by about $\frac{1}{16}$in. thick; having been cut to the proper length (about 11¾in.) it is bent into a circular form by being coiled round a cylinder about 4in. in diameter, the bending being facilitated especially at the ends of the strip by hammering with a mallet. The ring, when expanded, should be about 4½in. in diameter, and its ends, when compressed to 3¾in., should be about $\frac{1}{8}$in. apart. It is kept in position by its spring. A piece of cork, *k*, Fig. 1., is pushed into a hole made in *a* to receive it; into it the pivot, which consists of No. 6 sewing needle, is pushed, great care being taken to fix it in an absolutely vertical position with regard to the base *a*.

The needle system is shown in Fig. 4; *m* is a piece of glass tube about ⅛in. in diameter and ⅞in. long, with sides as thin as can be obtained; it is drawn to a point at one end—the conical cavity in this end, must not be too sharp, and it must be exactly central or the needle will not swing freely; *n n* are the needles, they each consist of two pieces of watch-spring 1⅜in. long by about $\frac{1}{16}$in. wide. These are magnetised, and each pair is whipped together at each end with sewing silk. Like poles should, of course, be together. These double magnets are then opened out in the middle and slipped over the glass tube. They should be in the same plane and have opposite poles on the same side of the tube, whose centre should, of course, be equidistant from their ends. They should also be in such a position on the tube that when the latter is placed in position on its pivot, the whole system swings freely, and without coming in contact with the bobbins or dial. The upper needle should be about $\frac{1}{16}$in. above the dial. A light pointer of aluminium or very thin sheet brass or copper pointed at each end, and as long as the diameter of the scale, and ⅛in. wide at its centre, is placed over the upper needle and at right angles to it. Both the needles and the pointer should be cemented in position with a thick cement made of sealing-wax dissolved in spirits of wine. As soon as this cement is dry the system should be placed on its pivot (the dial and bobbins having been removed) and carefully balanced by weighting the lower needle and the underside of the pointer as required, with sealing wax, until the tube hangs vertically on the pivot. The ends of the pointer should be slightly bent down towards the dial, as this facilitates accurate reading.

Previously to winding the bobbins the inside of each cheek should be covered with thin notepaper saturated in hot paraffin wax. The separating tubes between the outer and inner cheeks

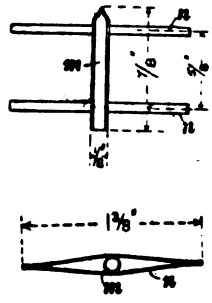

Fig. 4.—Pivotted Galvanometer. Needle system.

should also be covered with paraffined paper until their diameter reaches rather more than ¼in. A core of wood, 2½in. × 1in. × ¼in., well steeped in paraffin wax, should be pushed through the slots and the wire wound on in the usual manner. If fine wire be used, the first layer should not be thinner than No. 22 S.W.G.; over this a layer of notepaper should be placed. As in the last instrument described, each layer of wire should be treated with shellac varnish. The coils should be thoroughly dried before removing the core, and when finished should be covered with green silk ribbon. The ends of the wires should be soldered to the screws of the terminals. Terminals with double nuts, as shown, will be found extremely useful in this instrument.

If great sensitiveness is not required, the needle system need only have one magnetic needle. It will be found useful sometimes to have two needle systems, one astatic and the other single. Most instruments of this type are provided with an arrangement for lifting the needle system off the pivot. The best way to do this in the present case is to turn the instrument upside down when not in use.

The following diagram is Fig. 6 of the first article on "The Linesman's Detector," which appeared in *The Electrician* of

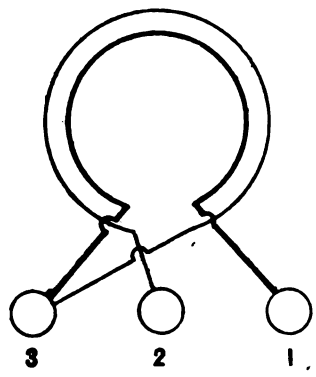

Fig. 6.

June 5th. This figure, which was inadvertently omitted from the article in question, shows the coil connections.

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VARIATIONS OF CONDUCTIVITY UNDER ELECTRICAL INFLUENCE.*

BY E. BRANLY.

The object of this article is to describe the first results obtained in an investigation of the variation of resistance of a large number of conductors under various electrical influences. The substances which up to the present have presented the greatest variations in conductivity are the powders or filings of metals. The enormous resistance offered by metal in a state of powder is well known; indeed, if we take a somewhat long column of very fine metallic powder the passage of the current is completely stopped. The increase in the electrical conductivity by pressure of powdered conducting substances is well known, and has had various practical applications. The variations of conductivity, however, which occur on subjecting conducting bodies to various electrical influences have not been previously investigated.

The Effect of Electric Sparks.—Let us take a circuit comprising a single cell, a galvanometer, and some powdered metal enclosed in an ebonite tube of 1 square centimetre cross section and a few centimetres long. Close the extremities of the tube with two cylindrical copper tubes pressing against the powdered metal and connected to the rest of the circuit. If the powder is sufficiently fine, even a very sensitive galvanometer does not show any evidence of a current passing. The resistance is of the order of millions of ohms, although the same metal melted or under pressure would only offer (the dimensions being the same) a resistance equal to a fraction of an ohm. There being, therefore, no current in the circuit, a Leyden jar is discharged at some little distance off, and the abrupt and permanent deflection of the galvanometer needle shows that an immediate and a permanent reduction of the resistance has been caused. The resistance of the metal is no longer to be measured in millions of ohms, but in hundreds. Its conductivity increases with the number and intensity of the sparks.

Some 20 or 30 centimetres from a circuit comprising some metallic filings contained in an ebonite cup, let us place a hollow brass sphere, 15 to 20 centimetres in diameter, insulated by a vertical glass support. The filings offer an enormous resistance and the galvanometer needle remains at zero. But if we bring an electrified stick of resin near the sphere, a little spark will pass between the stick and the sphere, and immediately the needle of the galvanometer is violently jerked and then remains permanently deflected. On some fresh filings being placed in the ebonite cup, the resistance of the circuit will again keep the needle at zero. If now the charged brass sphere is touched with the finger, there is a minute discharge and the galvanometer needle is again deflected. With a few accumulators the experiment can easily be made without a galvanometer. The circuit consists of the battery, some metallic powder, a platinum wire, and a mercury cup. The resistance of the powder is so high that the interuption of the circuit takes place without any sparking at the mercury cup. If now a Leyden jar is discharged in the neighbourhood of the circuit the powder is rendered conducting, the platinum wire immediately becomes red hot, and a violent spark occurs on breaking the circuit.

The influence of the spark decreases as the distance increases, but its influence is observable several metres away from the powder, even with a small Wimshurst machine. Repeating the spark increases the conductivity; in fact, with certain substances successive sparks produce successive jerks, and a gradually increasing and persistant deflection of the galvanometer.

Influence of a Conductor traversed by Condenser Discharges.—While using the Wimshurst machine it was noticed that the reduction in the resistance of the filings frequently took place before discharge. This led me to the following experiment: Take a long brass tube, one end of which is close to the circuit containing the metallic powder; its other end, several metres distant from the circuit, is fairly close to a charged Leyden jar. A spark takes place and the conductor is charged. At the same instant, the conductivity of the metallic powder is greatly increased.

The following arrangement, owing to its efficacy, convenience, and regularity of action was used by me in most of my researches, and I shall briefly call it the A arrangement (see Fig. 1).

The source of electricity is a two-plate Holtz machine driven at from 100 to 400 revolutions. A sensitive substance is introduced into one of the arms of a Wheatstone bridge, or into the circuit of a single Daniell cell at a distance of some 10 metres (34ft.) from the Holtz machine. Between the discharge knobs of the machine and the Wheatstone bridge, and connected to the former, there are two insulated brass tubes, A A′, running parallel to one another 40 centimetres apart. The Leyden jars usually attached to a Holtz machine may be dispensed with, the capacity of the long brass tubes being in some measure equivalent to them. The knobs S were 1mm., ·5mm., or ·1mm. apart. When the plates were rotated sparks rapidly succeeded each other. Experiments showed that these sparks had no direct effect at a distance of 10 metres. The two tubes A A′ are not absolutely necessary, the diminution of resistance is easily produced if only one is employed, and in some cases, indeed, a single conductor is more efficacious. An increase in the speed of the machine increases its action to a marked extent. The sparks at S may be suppressed by drawing the knobs apart, but the conductor A will still continue to exert its influence, especially if there is a spark gap anywhere about.

Effects of Induced Currents.—The passage of induced currents *through* a sensitive substance produces similar effects to those described above. In one instance an induction coil was taken, having two similar wires. The circuit of the secondary wire was closed through a tube containing filings, the galvanometer being also in circuit. Care was taken to ascertain before introducing the filings into the circuit that the currents on make and break gave equal and opposite deflections. Filings were then introduced into the circuit, the primary being made and broken at regular intervals. The following table gives the results obtained in the case of zinc filings:—

ZINC FILINGS.

Galvanometer throws.		Galvanometer throws.	
1st closing	1°	1st opening	18°
2nd „	64°	2nd „	109°
3rd „	146°	3rd „	140°

Effects of Passing Continuous Currents of High E.M.F.—If a continuous current of high E.M.F. is employed, it renders a sensitive substance conducting. The phenomenon may be shown in the following manner. A circuit is made up consisting of a battery, a sensitive substance, and a galvanometer. The E.M.F. of the battery is first one volt, then 100 volts, then one volt. Below I give the galvanometer deflections obtained with an E.M.F. of one volt for three different substances before and after the application of the E.M.F. of 100 volts:

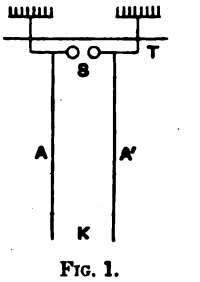

FIG. 1.

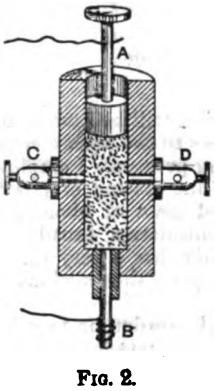

FIG. 2.

Before application of current.	After application of current.
16	100
0	15
1	500

In the case of some measurements taken on a Wheatstone bridge a prism of aluminium filings interposed between two copper electrodes offered a resistance of several million ohms before a high E.M.F. was applied, but only offered a resistance of 350 ohms after the application of this pressure for one minute. The time during which the powder should be interposed in the battery circuit should not be too short. Thus, in one instance the application for 10 seconds of 75 mercury sulphate cells produced no effect, but their application for 60 seconds resulted in the resistance being reduced from several megohms to 2,500 ohms.

It should be observed that the phenomenon of suddenly increased conductivity occurs even if the sensitive substance is not in circuit with a battery at the time it is influenced. Thus, the metallic filings, after having been placed in circuit with a Daniell cell, and its high resistance observed, may then be completely insulated and submitted in this condition to the action of a distant spark, or of a charged rod, or of induced currents. If, after this, the filings are replaced in their original circuit the enormous increase in their conductivity is immediately apparent.

The conductivity produced by these various methods takes place throughout the whole mass of the metallic filings, and in every direction, as the following experiment will show. A vertical ebonite cup containing aluminium powder (*see* Fig. 2) is placed between two metal plates A, B, laterally the powder is in contact with two short rods C, D, which pass through the sides of the ebonite cylinder. A and B can be connected to two terminals of one of the arms of the Wheatstone bridge, C and D being free, and

* Abstract of an article in *La Lumière Electrique*, May 16, 1891.

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vice versâ. Whatever arrangement is adopted, if a battery of 100 cells is joined up for a few seconds with one or the other of the pairs of terminals, the increase in the conductivity is immediately visible in that direction, and is found to exist also in the direction at right angles.

Substances in which Diminution of Resistance has been Observed.—The substances in which the phenomenon of the sudden increase of conductivity is most easily observed are filings of iron, aluminium, copper, brass, antimony, tellurium, cadmium, zinc, bismuth, &c. The size of the grains and their nature are not the only elements to be considered, for grains of lead of the same size, but coming from different quarters, offer at the same temperature great differences in resistance (20,000 to 500,000 ohms). Extremely fine metallic powder, as a rule, offers almost perfect resistance to the passage of a current. But if we take a sufficiently short column and exert a sufficiently great pressure a point is soon reached when the electrical influence will effect a sudden increase in the conductivity. Thus, a layer of copper reduced by hydrogen, which does not become conducting under the influence of the electric spark or

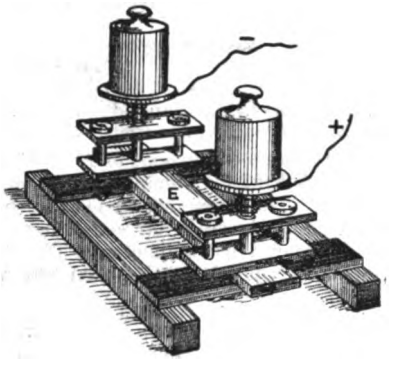

Fig 3.

otherwise, will become so on being submitted to a pressure of 500 grammes to the square centimetre (7lb. per square inch). Instead of using pressure, I employed as a conductor in some experiments a very fine coating of powdered copper spread on a sheet of unpolished glass or ebonite E (Fig. 3), seven centimetres long and two centimetres broad. A layer of this kind, polished with a burnisher, has a very variable resistance. With a little care one can prepare sheets which are more or less sensitive to electrical action.

Metal powder or metal filings are not the only sensitive substances, as powdered galena, which is slightly conducting under pressure, conducts much better after having been submitted to electrical influence. Powdered binoxide of manganese is not very sensitive unless mixed with powdered antimony and compressed.

Making use of the A arrangement with very short sparks at S (Fig. 1), the phenomenon of increased conductivity can be observed with platinised and silvered glass, also with glass covered with gold,

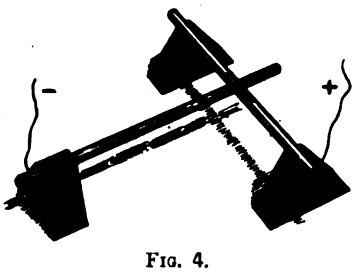

Fig. 4.

silver, and aluminium foil. Some of the mixtures employed had the consistency of paste. These were mixtures of colza oil and iron, or antimony filings, and of ether or petroleum and aluminium, and plumbago, &c. Other mixtures were solid. If we make a mixture of iron filings and Canada balsam, melted in a water bath, and pour the paste into a little ebonite cup, the ends of which are closed by metallic rods, a substance is obtained which solidifies on cooling. The resistance of such a mixture is lowered from several megohms to a few hundred ohms by an electric spark. Similar results are obtained with a solid rod composed of fused flowers of sulphur and iron or aluminium filings, also by a mixture of melted resin and aluminium filings. In the preparation of these solid sensitive mixtures, care must be taken that the insulating substance should only form a small percentage of the whole.

Some interesting results are also obtained with mixtures of sulphur and aluminium, and with resin and aluminium, when in a state of powder. When cold these mixtures as a rule do not conduct either directly or after they have been exposed to electrical influences, but they become conducting on combining pressure with electrical influences. Thus, a mixture of flowers of sulphur and aluminium filings in equal volumes was placed in a glass tube 24mm. in diameter. The weight of the mixture was 20 grammes, and the height of the column 22mm.; with a pressure of 186 grammes per square centimetre (2¼lb. per square inch). The mixture is not conducting, but after exposure to electrical influence, obtained by the A arrangement, the resistance falls to 90 ohms. In a similar manner a mixture of selenium and aluminium, placed in a tube 99mm. long, was not conducting until after it was exposed to the combined influence of pressure and electricity.

The following is one of the group of numerous experiments of a slightly different character. A mixture of flowers of sulphur and fine aluminium filings, containing two of sulphur to one of aluminium, is placed in a cylindrical glass tube 35mm. long. By means of a piston, a pressure of 20 kilogrammes per square centimetre (284lb. per square inch) was applied. It was only necessary to connect the column for 10 seconds to the poles of a 25 cell battery, for the resistance originally infinite to be reduced to 4,000 ohms.

The arrangement shown in Fig. 4 illustrates another order of experiment. Two rods of copper were oxidised in the flame of a Bunsen burner, and were then arranged to lie across each other, as shown, and were connected to the terminals of the arm of a Wheatstone bridge, the high resistance of the circuit being due to the layers of oxide. Amongst the many measurements made, I found, in one case, a resistance of 80,000 ohms, which, after exposure to the influence of the electric spark, was reduced to 7 ohms. Analogous effects are obtained with oxidised steel rods. Another pretty experiment is to place a cylinder of copper, with an oxidised hemispherical head, on a sheet of oxidised copper. Before exposure to the influence of the electric spark, the oxide offers considerable resistance. The experiment can be repeated several times by merely moving the cylinder from one place to another on the oxidised sheet of copper, thus showing that the phenomenon only takes place at the point of contact of the two layers of oxide.

In conclusion, it may be worth noting that, for most of the substances enumerated, an elevation of temperature diminishes the resistance, but the effect of a rise of temperature is transient, and is incomparably less than the effect due to currents of high potential. For a few substances the two effects are opposed.

HIGH-TENSION EXPERIMENTS.

Experiments with currents of excessively high tension are very much *à la mode* just at present, and the following abstract of an account which has appeared in the *Elektrotechnische Rundschau* of some which were publicly carried out last April, in Siemens and Halske's works at Charlottenburg, may prove interesting. The apparatus (see Fig. 1) comprised a 25 H.P. 1,000-volt alternator excited by current from a battery of accumulators. The current from the alternator was taken to a step-up transformer (1,000—20,000 volts), thence along a line to two step-down transformers (20,000—1,000 volts and 1,000—100 volts). The actual existence of the 20,000 volts was rendered visible by the illumination of 200 100-volt incandescent lamps arranged in series across the terminals A B of the first transformer.

According to Herr Kopsel, who conducted the demonstration, the only possible solid insulator for high pressure work is specially prepared vulcanised india-rubber. A sheet of vulcanised india-rubber 1·5mm. thick, and prepared by a special process of Siemens and Halske, was then exposed to a pressure of over 20,000 volts without its being pierced, or, indeed, suffering in any way. Various cables were then exposed to high voltages; one gave at 16,000 volts, and another successfully withstood more than 20,000 volts.

When testing solid insulating bodies, the apparatus shown in Fig. 2 was employed, *m m* being two metal plates in connection with the terminals A B, and J being the substance under test. In order to protect the transformer on the breakdown of the insulation the 200 100-volt lamps were connected in series with the plates *m m*, which arrangement also rendered the rupture of the insulation visible to all present by the incandescing of the lamps. A piece of compressed cardboard 1mm. thick broke down at 2,000 volts, and a sheet of glass of the same thickness gave out when about 10,000 volts were applied. In the case of the latter a beautiful luminous phenomenon was witnessed. A blue glow appeared all round the edge of the brass discs, where they were in contact with the glass, the glow being accompanied by a sharp crackling. When testing liquid insulating bodies the apparatus shown in Fig. 3 was employed. Two brass plates, *m m*, were placed in a glass vessel containing the liquid to be tested, the plates being kept in position by vulcanite distance pieces, *a b c*. The experiments showed that although oil was an excellent insulator it lost this

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quality in a large measure after it had once been pierced by a spark. *After* the passage of a spark it frequently broke down at 4,000 volts. The reason given was the decomposition of the oil by the spark, and the consequent formation of a sort of conducting bridge of carbon particles.

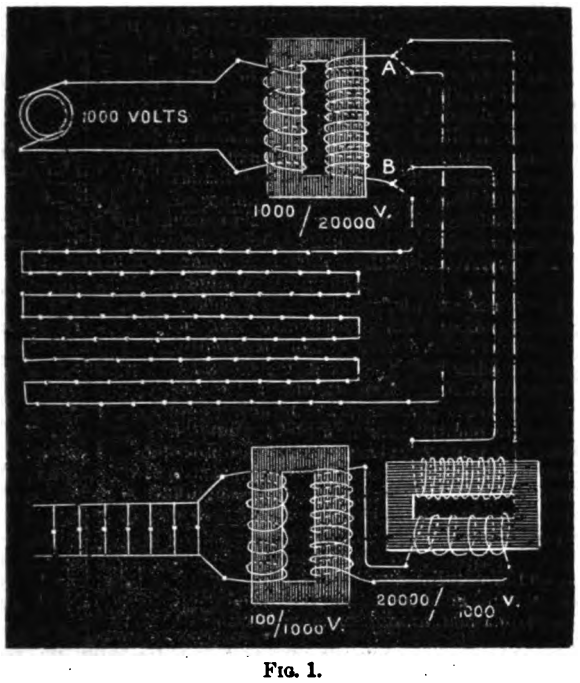

FIG. 1.

Experiments were then made to show the distribution of potential in a transformer. A number of tinfoil electroscopes were connected to a rod of vulcanite, X Y (Fig. 4). On connecting electroscopes to the points A B and C, the leaves at A B diverged, while those at C remained closed; showing that the potential at this

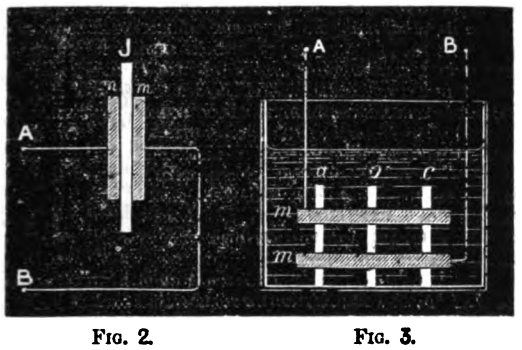

FIG. 2. FIG. 3.

point was the same as that of the earth. If a second transformer was connected up, as shown in the figure, by a wire B*f*, sparks could be drawn from the iron core of this transformer as well as from the secondary coil. Judging by the length of the sparks their potential was equal to the potential of B. The leaves of an electroscope con-

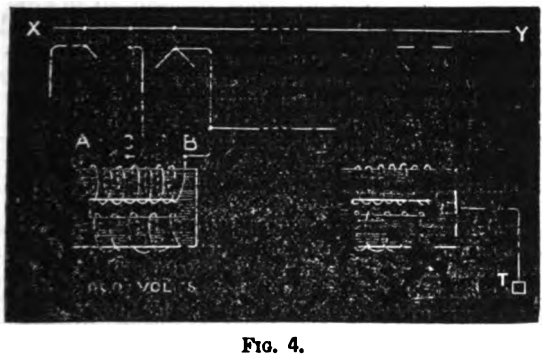

FIG. 4.

nected to the core diverged widely. The distribution of potential was also rendered visible by connecting up the 200 100-volt lamps. While carrying out this experiment, it was observed that the carbon filaments of the lamps nearest the ends of the series vibrated so energetically that at times they struck the bulbs. This phenomenon may be attributed to electrostatic action between the filaments and the glass, and the effect was more marked at the terminals because of the greater difference of potential. On connecting up one end only of the lamps to the transformer, and by choosing lamps with the proper degree of exhaustion, the whole series was made to phosphoresce. This phenomenon may be explained if the globes and the filaments have all the same difference of potential between them; equilibrium would then be produced by a silent discharge. Several experiments on the sparking distances in air of various high pressures were then performed.

THE PRACTICAL ASPECTS OF ELECTRIC WELDING.*

BY FREDERICK A. C. PERRINE, D.SC.

It is hardly necessary to give any description of the general process of electric welding to the Institute of Electrical Engineers. I intend rather to speak of it in actual use, and to discuss some of the problems involved.

The plant with which I have been intimately connected, though not one of the heaviest, is still one making a great number of successful welds in a day, and is one in which the joints are required to be of the highest character, and are subjected to the severest tests. The first machine actually sold by the welding company was bought by the Roeblings, but on account of the delay of the engine builders it was not in place and running for some six months, three or four months after other machines were in satisfactory operation. This was of the direct type, having a double winding on the armature, and the welding done on an apron immediately above the collector terminals of the heavy alternating coils; the pressure was applied by a handle regulated by the workman, the projection also being regulated by a scale stamped on the cam of the handle. Though considered crude, this machine did satisfactory work, often for 24 hours a day, and six days in the week, for about two years, having made about 370,000 splices in telegraph wire during its useful life.

After the automatic machines were brought to a reasonable perfection, we purchased a generator capable of welding up to ½in. copper (40,000 watts), and installed one large transformer, and seven smaller ones of capacity from No. 4 B. and S. copper to No. 18 B and S. These have been at the works something less than one year, and show a daily record of over 1,000 welds in copper and iron wire.

Our attention was drawn to the process at first as a possible solution of a very troublesome problem in preparing and packing iron telegraph wire. For the convenience of the telegraph companies this wire must be put up in bundles, measuring each exactly one-half mile of continuous length. It is very easy to say that the proper weight billets may be bought, and the pieces kept continuous through all the process of manufacture; but, as a fact, these pieces are necessarily irregular in original size, and are often broken in the process of manufacture, and, in consequence, it has long been the custom to make the proper weight bundles by recoiling and splicing with the common telegraph or Lippman's joint, after the wire has been galvanised, jointing before galvanising having proved a failure on account of the acid carried over into the zinc pans by the great helix of the joints.

Singularly enough, the telegraph companies which had for so long accepted as satisfactory these cumbrous connections, immediately commenced to complain of the large burr left by the welding machine, and which we had thought unnecessary to remove. An emery wheel solved this difficulty, however, and we were then able to defy them to find the joint at all. After a very complete series of tests on the joints themselves, the telegraph companies have been finally satisfied, and we are now able to make our bundles of the proper weight and length before the galvanising is put on, and thus save one re-handling of nearly our whole product, besides having removed one of the greatest difficulties and causes of complaint.

"Shorts," as they are technically termed, in copper, are, of course, a still more serious source of loss, not only on account of the greater value of the material, but also on account of the greater liability of this weaker metal to break in the process of drawing, and also on account of the necessarily defective character of a joint in the insulation with which copper wire is usually covered when sent out from the factory. Cables, as you all know, must be made in exact lengths, many of which are often very great, and though a twisted soldered joint might be satisfactory at the bottom of the sea, or covered by a lead sleeve in a manhole, it could not for an instant be tolerated in the body of a cable, which must, before completion of the cable, be passed through exact dies for covering with rubber or lead. Before the introduction of these machines, our custom had been to carefully scarf and fit the joint, which was then brazed with silver solder. While this method makes a strong

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joint, but little increased in resistance, and thoroughly satisfactory in other respects, it has the disadvantage of being rather slow and difficult to produce, on account of the necessary care in fitting the scarfed ends as well as in soldering and finishing.

Since last November three boys on three machines have made respectively in this work 10,570 welds, 7,642 welds, and 20,421 welds, the registers having been taken on April 16th. Every weld is tested by bending and straining, and if one shows any weakness it is quickly cut out and made again, with the loss only of a very small amount of time and the royalty to the welding company. In all of our welding of sizes below ¼in. the ends are prepared by cutting square across with a pair of pliers, and then setting the cuts at right angles to each other, touching only at the centre, from which the heat radiates to the surface; then, after completion of the weld, the burr is removed by an emery wheel from the iron wire, and by a file from the copper. The preparation and finishing is a little more complex in the larger sizes; the ends are filed to a true butt and chamfered at the edges, and after a reheating in separate clamps the burr of the weld is forged to the diameter of the original rod. The necessity of this will be apparent later on. All of this work is done on either soft steel or copper wire, and is probably of the simplest character done on any machines made by the welding company, consequently the advantages are not so apparent as where the welds are difficult in character on account of complicated shapes.

More varied work is done by the companies of whose plants I now give slight descriptions which may prove interesting. Messrs. Seward and Son, of New Haven, Conn., have at work a machine of somewhat universal character, its employment being principally in uniting Norway iron to Swedish steel, in such shapes as are required in carriage irons and fifth wheels. In this work the burr is removed by a drop hammer at the same heat by which the weld has been made. The crescent tyres of the hundreds of bicycles manufactured by the Pope Manufacturing Company are welded and afterwards formed by dies at the same heat. The material is soft steel. These people also have a machine for brazing their small parts. Besides using the electric welding machine for their telegraph wire, the Trenton Iron Company, of Trenton, N.J., have boldly attempted to make a weld in a wire rope to avoid the tedious, and, with their locked wire rope, impossible operation of splicing. The ordinary joint in a wire rope is from 10 to 20ft. in length, and requires considerable skill on the part of the splicer and his assistants. The operation is to re-twist bunches of wire from opposite strands, and to tuck the loose ends under the adjacent complete strands, which then hold them in place. With the locked wire rope, which is itself but a single strand, the only successful method of joining opposite ends has been to fasten securely around each a cast-iron collar, and, after abutting the ends in a welding machine, to cement the whole together, and afterwards to break off the cast-iron collar, leaving the rope as a solid bar for about 2in. at the weld.

One of the largest and most complete plants at present in operation is that of the Studebaker Bros. Manufacturing Company, of South Bend, Ind. They have at present nine machines; one of them for steel axles up to 1½in. square. After the weld is made it is quickly removed to a drop hammer, making about 300 blows a minute, then at the same heat the axle is set ready for the market. The test for these axles is to bend to 90deg. while hot, and then back to alignment. No instance has yet been reported of an axle breaking under this test, which is frequently made to insure perfect workmanship. They have two machines for welding large car tyres, about 4in. wide and ¾in. thick, and smaller sizes. The weld is made in the usual way and then quickly removed to a hammer, where, by vertical and side blows, the burr is quickly removed. One hammer will easily take care of two welders in constant operation. They have two machines for the hub bands, which are used on the waggon wheels, and they are able to turn out about 1,200 on each machine; besides these there are two or three machines for smaller miscellaneous work. All of the metal used by them is either iron or low grade steel. After the introduction of their plant, their machines made 360,000 welds in less than six months.

Probably the heaviest work done at present in electric welding is that of the Johnson Rail Company, of Johnstown, Pa, who are not, as stated in the journals, welding long lengths of rails together, since, with their continuous mill, they already roll a rail too long to ship, but they find economy in the process in some details of their smaller manufactures. As to the results in general, they say:—"We would state that over a year ago we put in one welder for general work. The bulk of the work done on this machine was work we had totally failed to do by hand welding, not on account of the difficulty of the weld, but on account of the general unreliability of the result. The result of a year's use of the electric welder was, that we have not known one of the welds made by the method to fail, and we have closed contracts with the welding company for four 40,000 watt machines and two 80,000 watt machines, with the intention of adopting the method extensively in our works."

Agricultural machinery has generally been furnished with iron wheels, consisting of a malleable iron hub, into which the spokes are upset, and of a rim into which they are upset at the opposite end. The electro-welding machine has given us two new wheels, each of which is supposed to be preferable to the one described. In the first, manufactured by the Electric Wheel Company, of Quincy, Ill., the hub is cast of malleable iron, with spokes about 3in. long. To these are welded, by one machine, wrought-iron spokes, and, again, by another machine, these spokes are upset into the rim, which is itself welded into a tyre, the product being a wheel of which the spokes are less liable to rattle loose at the hub. The second method is that of Niles and Spott, La Porte, Ind. The hub in this case is composed of two drop forgings of low grade steel, grooved to receive the spokes; one-half is placed on the base of the welder, and the spokes laid in their grooves, then the other half of the hub is put on and the clamp brought down. The current is then applied and the whole, spokes and hub, welded solidly.

The Rogers Typographic Company, Cleveland, Ohio, are practically welding brass to steel, making as many as 800 welds per day, and thus effecting a great saving in the manufacture of their type-setting and founding machines. The hardest steel at present successfully worked by this process is the welding of band saws by the E. C. Atkins Company, of Indianapolis, Ind.; besides the regular work of making the joint in continuous band-saws, these people have ingeniously adopted this method for replacing broken teeth in finished saws. Formerly, they were compelled to cut down to a smaller size any saws from which one or two teeth had been accidentally broken, thus losing not only the difference in price between the two saws, but also the entire cost of labour in cutting the original saw. At present, when a tooth is broken out, they fit in it a new tooth, which is electrically welded in place, and a drop of oil applied at the completing of the heat restores the temper to a serviceable point. Pipe welding, which we all saw successfully accomplished at the factory last year, is put in practice by several companies.

The Electric Pipe Bending Company is engaged principally in manufacturing long continuous coils for ice machines, blast furnace tuyeres, and radiators. With this machinery they not only weld extra heavy black pipe, but also electrically heat the pipe with a machine 20in. between the clamps for the purpose of bending to desired shapes over pipe formers. With continuous coils of pipe it has been necessary for a smith to weld the whole length, 150 to 200ft., before attempting to bend any portion of it, and then after once the bending operation has commenced, in order to get a uniform spiral, the heat is not altered or the bending operation suspended till the coil is complete. Under the present electrical methods the coils are continuously heated in a fire, and the coiling is continuous while one length of pipe is welded at a time, the operation being to attach the welding machine to the end of the moving pipe, and while the forward portion is undergoing the process of bending to weld on a new length, which will be accomplished in a sufficiently short time not to interfere with the coiling apparatus. In all of this pipe welding the burr is beaten down by means of a pneumatic hammer, which is put in rapid motion by the act of closing it around the pipe, a rapid hammer having proved much more effectual than any press or dies. This is probably on account of the more rapid cooling action of the press, since no forming is attempted before the weld is completed and the current is turned off.

For the Charlestown Navy Yard there is about completed a machine for welding ship chains up to 2in. diameter links. These links are formed in halves and fitted roughly to each other, the welds being made in both sides at once by the same heat, which can be regulated to force either side at the will of the operator. When completed, both welds are forged immediately in a die by the same hammer. By this method only the points to be welded are heated, and, as these are immediately forged, one could expect from the process a nearer approach to the strength of rolled metal than where the whole link is heated in the ordinary fire to a welding temperature. The latest development for Government work is the manufacture of conical shell and shrapnel for the smaller armour-piercing guns. With the modern types of armour a cast shell is not of sufficient strength to resist the shock of impact, and in consequence a chrome-steel point is welded to a tool-steel body, embracing the powder cavity. This latter is but small in comparison with that in the old round shell of revolutionary days, consequently the accurate forging of the interior becomes correspondingly difficult. The electrically welded shells are made entirely of forged point, body and base, which may be finished to approximate dimensions, these requiring after welding a minimum amount of machining. The tests on these shells have resulted in a contract for a large number under a guarantee of the manufacturing company.

For a rod to be subjected to further drawing, rolling, or other like processes of manufacture, the weld is satisfactory, since the subsequent working reinstates the metal to its best condition, but

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for a wire to be considered a finished product, further manipulation is necessary. In view of this, the later machines for welding heavy copper have been provided with reheating clamps and light rapid hammers, by means of which the burr, after a slight trimming, can be reheated and forged; in special cases a further hammering cold is added. Though this produces a great improvement in the metal, it yet leaves a good deal to be desired where great strength and pliability are required. To produce this, a further upsetting of the metal throughout the whole heated space and a subsequent forging will be necessary. This, up to the present time, has not been provided for, and presents a greater difficulty than is at first apparent, besides furnishing a new proof of the crystalline constitution of copper. On account of this characteristic, as is apparent on attempting upsetting in the welding machine, it offers, at a red heat capable of moving and rearranging the particles, a resistance so high to compression, that three or four times the pressure necessary for welding will not have the slightest effect towards increasing the diameter or upsetting. With bronzes the further difficulty is encountered of red shortness between the molten temperature of the weld and the malleable red temperature. That this should be so necessary and offer so many difficulties may seem strange, since the metal does not apparently exceed the temperature of ordinary annealing, and it must be that either the passage of the current by an extra disturbance helps to rearrange the particles, or else the temperature is greater than we imagine from an observation. The latter explanation seems to me to be the more likely, since our ordinary observations are made on metals heated from an external source, and of which the surface is at the highest temperature. With the weld, however, the source of heat is internal, and the surface is undergoing a continual cooling from the external air.

Welds made in the higher carbon steels are at a similar disadvantage, and must be looked upon with disfavour unless provision for upsetting and forging hot is provided. These disadvantages are especially apparent with steel wires of the highest grade, where the strength of the original material has been more than doubled by tempering and drawing. In such cases it is not ordinarily the loss of tensile strength that is to be feared, but the increased liability to snap under repeated bendings. This is especially important in the case of wire to be twisted into a running rope, such as is used on our cable railroads. From this view, the weld in a whole rope where forging is impossible would be necessarily defective, and though for a standing rope I have no doubt it would be fairly successful, yet for a running rope I believe everything tends to prove it dangerous. It has been suggested as an explanation that these effects are due to the presence of oxygen at the weld, producing suboxide in copper and reducing the carbon in steel. In support of this view the case of the application of oil to the hard saw teeth is cited as supplying the necessary carbon by its decomposition. It is undoubtedly a fact that by the heating of these high grade steels, and subsequent slow cooling, some of the combined carbon is changed to the graphitic form, with a consequent loss of strength, and it seems clear to me that a drop of oil at the right moment serves to restore this, or, in other words, effects a tempering. It is almost useless to attempt an explanation by a complicated chemical decomposition, when the simpler molecular rearrangement is more in accordance with the facts and a more complete explanation.

This brings us to a point where the electric welding throws light upon the actual production and nature of burnt steel. By forcing the heat in welding, no matter if rapidly, this effect can be produced as thoroughly as by the means of a fire; while if the name "burnt" was an accurate description, and the iron and carbon oxidised, a sufficient time would be necessary for its penetration into the centre of a bar of metal. This agrees, and is a further confirmation of the most modern ideas about burnt metal, that it is a molecular rearrangement, and by careful forging and heating the metal can be restored to its original state. In this case oxidation certainly does not take place, though the action may be similar to metamorphism in rocks; steel being at the present day looked upon as a mineral, a matrix of iron including minerals which are generally compounds of iron with carbon, silicon, sulphur, manganese or phosphorus. Under this view there may be internal chemical rearrangement at high temperature. With carbon we know this to be the case, but I take it as settled by electrical heating that the change is not necessarily an oxidation.

The welding of two different materials, such as iron and steel or malleable cast-iron, presents another difficulty and possible danger. When such a weld is broken we find that the pressure in the plastic state has forced the iron over the steel, which has itself been merely slightly melted and cemented to the adjacent particles of the iron. This produces what might be called a reverse riveting, the hot iron having been upset over the steel and enclosing it tightly, in the place of having been upset in a hole as in ordinary riveting. Again, as in all this work, the tensile test is but a poor test of quality, and though a weld may have within 10 or 20 per cent. the tensile strength of one of the original materials, it is a fallacy to say that therefore the weld is within 10 or 20 per cent. of the quality of either of them. Use here again determines the serviceableness of the process.

I am tempted here to carry further the discussion of the special cases offered, but it would only be to apply over again the observation indicated in the foregoing, and which might be finally stated that, although the electric welding process will not practically splice everything from a bar of magnesium to a steamer shaft, yet it enables us to accomplish results otherwise impossible, and, if both the use of the product and the treatment of the materials be sufficiently studied, it may be trusted in its results.

LONDON CHAMBER OF COMMERCE.

MEETING OF THE COMMITTEE OF THE ELECTRICAL TRADE SECTION.

A meeting of the Committee of the Electrical Trade Section of the London Chamber of Commerce was held at three o'clock, on Monday last, at the offices of the Chamber, Botolph House, Eastcheap. Amongst those present were Messrs. R. E. Crompton, C. J. Wharton, R. S. Erskine, H. G. Massingham, George Offor, Moritz Immisch, and Bennett Pell.

After the reading of the minutes of the last meeting, the CHAIRMAN (Mr. C. J. Wharton) said that the Secretary (Mr. Murray) had written a strong letter to the Board of Trade with reference to the telephone clauses in the Electric Lighting Orders, in the terms of the resolution passed at the meeting of the Committee on March 20th. The reply of the Board of Trade was then read, in which it was stated that it had always been their object to draw up Provisional Orders which should satisfy both parties. In consequence of the unsatisfactory nature of this reply the Secretary said that, after some consultation, it was decided to abandon the idea of a deputation to the Board of Trade, and to let the matter drop. The Secretary then read Mr. Thomas Parker's report with reference to the proceedings of the Electrical Standards Committee, in which he stated that amongst other things it was proposed to appoint inspectors in certain towns for the purpose of verifying and stamping electrical standard instruments. It was then stated that a letter had been received from Mr. J. E. H. Gordon, enclosing one from his partner, Mr. Rivington, giving particulars of Prof. Mengarini's Tivoli-Rome electrical transmission of power plans.

It was decided to enter Mr. Parker's report on the minutes.

The CHAIRMAN said that although the experience of his firm was that the Board of Trade overhead wire rules were unnecessarily stringent, and his firm had done all they could to obtain their modification, the Board of Trade had refused to move. Under the circumstances, however, he thought it would be inadvisable to forward, as Mr. Gordon suggested, the particulars of Prof. Mengarini's proposed transmission of high-pressure currents by bare overhead wires until the thing was a *fait accompli*.

The SECRETARY then gave the results of the circulars sent out by him to all members of the section with reference to the proposed Electrical Exhibition at the Crystal Palace. Some ten firms were in favour of participating, most of them, however, upon conditions. Some eight or nine firms did not propose to exhibit, and about the same number would like a postponement. Amongst the firms proposing to exhibit were the Edison-Swan Company, Paterson and Cooper, the Acme Electric Works, Ernest Scott and Mountain, &c. The Brush Company thought that there was no call for an exhibition at present, but were prepared to follow the views of the trade generally. Messrs. Goolden and Co. were in favour of postponement, and did not intend to exhibit this year. Major Flood-Page wrote to the effect that he was of opinion that the Exhibition should be postponed until next year, to admit of its being made really international and thoroughly representative, and that in that case the assistance of the Electrical Trade Section and of the Council of the Institution of Electrical Engineers might well be asked for. He suggested that the Secretary should be requested to write to the Crystal Palace authorities asking them to meet the Committee with a view to coming to an agreement favourable to their mutual interests.

A discussion ensued. One member suggested that Olympia was a more suitable place than the Crystal Palace, and there was a general consensus of opinion in favour of the postponement of the Exhibition until 1892. It was finally decided to adopt the suggestion contained in Major Flood-Page's letter to the Secretary, and to ask the Crystal Palace authorities to meet the Committee.

Mr. R. E. Crompton now entered the room and took the chair.

Mr. MASSINGHAM said that the object of the Taunton Exhibition was simply to popularise the electric light throughout the West of England. It was a purely local affair, promoted by the Taunton,

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Bath, and Exeter Companies, and the space available was very limited. It seemed to him hardly worth while for the Section to take any notice of it, one way or the other.

The CHAIRMAN thought that, with a view of encouraging the scheme, the Secretary might be instructed to write to the Exhibition promoters to the effect that the Committee was in favour of local exhibitions of the kind and wished it every success. This was agreed to.

The notice on the agenda with reference to the Frankfort Exhibition was then discussed.

The CHAIRMAN said the question before them was whether the Electrical Section of the Chamber should meet at the Frankfort Exhibition in a body, thus securing such benefits in the way of formal receptions, guides, &c., as accrued from such a mode of proceeding. He had written to the executive of the Exhibition on the matter, and had received a favourable reply. Two dates had been proposed for the visit, namely, August 5th to 15th, and September 5th to 15th.

It was agreed to circularise the Section on the subject.

Communications were then read with reference to Patent Law reform and confidential trade reports from Germany, and the proceedings terminated.

PARLIAMENTARY INTELLIGENCE.

HOUSE OF LORDS SELECT COMMITTEE CENTRAL LONDON RAILWAY BILL.

The Bill for constructing an underground electric railway from Shepherd's Bush to Cornhill came before a Committee of the House of Lords on Tuesday, Lord Elgin being Chairman.

The promoters were represented by Mr. Pember, Q.C., Mr. Saunders, Q.C., Mr. Freeman, and Mr. Munro. Petitions against the Bill were lodged by the Marylebone Vestry (represented by Mr. Cripps, Q.C.), by the frontagers, lessees, owners and occupiers (represented by Mr. Rigg and Mr. Lewis Coward), by Mr. Maurice Powell, a leaseholder in possession at 2, Kensington Palace Gardens, who appeared in person; and by the London County Council, though the Council was not represented by counsel.

The proposed stations on the line are to be 13 in number, and situated at Shepherd's Bush, Lansdown-road, Notting Hill Gate, Queen's-road, Westbourne station, Marble Arch, Davies-street, Oxford Circus, Tottenham Court-road, Bloomsbury, Chancery-lane, Newgate-street, and Cornhill.

Mr. PEMBER, Q.C., opening his case on the preamble for the promoters, said he had hoped to have spared the Committee from the trouble of many of the details of the Bill, expecting that what opposition was forthcoming would be confined to clauses; but at the last moment petitions traversing the preamble had been lodged. The Bill had twice passed the House of Commons, though it had once had the misfortune of being thrown out by a Committee of the Lords. The motives for the objection on that occasion had, however, been largely removed since that time. Most of the discussion, however, would be on clauses. The line began at Shepherd's Bush and terminated at Cornhill, the entire length being about six miles. There was a small street improvement scheme at Davies-street station included in the Bill, which would be explained by the engineer. The proposed depth of the line would be 50ft. below the surface, which would at once ensure isolation, do away with vibration, and prevent any possible annoyance to anybody on the route. The route traversed would be Oxford-street, New Oxford-street, Holborn Viaduct, and Cheapside. On the point of the utility of the line Mr. Pember said that it had been found that the Metropolitan Railway and the District Line, by avoiding main thoroughfares had been in error, but that very fact showed that the proposed line would not interfere with either of those lines. During the construction of the proposed line Mr. Pember said that no one would suffer any annoyance or impediment to business; and, secondly, there would be no vibration, or smoke, or noise, in working the line. Further, there would be no disfigurement of the streets by girder bridges, as in an overground line. The method of construction would be the same as that adopted on the City and South London Electric Railway. The electric power would be generated at a fixed station at Shepherd's Bush. The great depth (50ft.) of the tunnel would abolish all chance or danger of subsidence. The tunnel tubes would be inserted, and finally fixed in short lengths, and the tubes themselves would have an inside diameter of 11ft. 6in. Hydraulic lifts woud be provided for conveying passengers up and down at each station. It was expected that a speed of 25 miles an hour would be reached, inclusive of the stoppages, which would make an average of about 25 per cent. greater speed than that made on the Inner Circle Railway. The journey from the Marble Arch to the Bank would occupy about 15 minutes, and the entire journey 25 minutes. It was, Mr. Pember said, impossible for London to have another above-ground railway, and it only remained that the traffic should be met in the manner suggested in the Bill. The capital of the promoting Company was between two and two and a-half millions.

Dealing with the opposing petitions, Mr. MAURICE POWELL objected on the ground of being a leaseholder in possession at 2, Kensington Palace-gardens, Paddington, and that, as the proposed line would traverse his subsoil, it would rob him of that subsoil, and also deprive him of the use and enjoyment of certain springs, now yielding him a water supply.

Mr. PEMBER contended that there would be no such dangers as the petitioner feared, and he thought no arbitrator would award much money damages to Mr. Powell. Referring to the petition against the Bill from the frontagers, owners, lessees, and occupiers, Mr. Pember contended that the real basis of the opposition was that, as the proposed line would remove the foot-passenger traffic, their shop trade would suffer.

Mr. GREATHEAD, C.E., was then called, and examined by Mr. Saunders, Q.C. Witness deposed to considerable experience in railway construction, and of late years he had almost exclusively confined himself to tunnelling for railway purposes. He was engineer and inventor of the system carried out on the City and South London Railway. On the proposed line the greatest gradient would be 1 in 100, as compared with 1 in 30 on the South London line. The Bill had a clause forbidding the tunnel to be nearer than 20 feet below the surface at any point. At the stations the tunnel tubes would be about 21 feet diameter. Each train would have six carriages, and would carry 336 passengers. The total cost of the line, with all general contingencies, would be £2,053,000, and for special contingencies £123,000, for electric plant £600,000, and, adding expenses of promotion, &c., the total would be £3,073,000. The capital cost per mile would be £600,000 per mile.

Sir THOMAS FARRER was examined by consent of the Committee and counsel. He was a resident in Marylebone, and knew the points of opposition raised last year by the Vestry. That Vestry were not satisfied with the scheme, on principle, and Sir Thomas, both as a private individual, a ratepayer, and as a public man on the London County Council, was in thorough accord with the scheme. The construction of the line would greatly relieve the surface traffic of the main thoroughfares, and would, therefore, relieve the ratepayers of much of the capital cost of paving, &c., and also of maintenance and repairs. The proposed railway, unlike other railways, would destroy no rateable property, but would create new rateable property. He deemed the scheme extremely important to inhabitants of London, and that was why he, as a public man, appeared in support of it.

Cross-examined by Mr. Rigg: Witness did not think the railway would affect the trade of shopkeepers on the route, and even if it did it was a selfish interest of the shopkeepers not to be compared with the public good.

Mr. GREATHEAD was then recalled, and his cross-examination by Mr. Rigg continued. Witness admitted that, in constructing the City and South London Railway, damage had been done to some houses to some extent, but it was very little, and the claims for compensation were not at all heavy. Witness estimated the cost of working the line at 9d. per train mile.

Sir BENJAMIN BAKER, C.E., was next examined by Mr. Saunders, Q.C. In respect of the alleged probable damage to buildings by the line, witness cited the underpinning of the houses of Cannon-street, which was done with safety, and therefore no danger could accrue by this line, which was not under houses at all. After slight cross-examination, which had no weight, the witness withdrew.

Sir JOHN FOWLER, C.E., then gave evidence in favour of the line.

Sir JAMES WHITEHEAD, representing the Ward of Cheap, strongly favoured the proposed line, as tending to the commercial benefit of the City traders.

Dr. HOPKINSON, consulting engineer for the new line, tendered evidence on electrical technicalities.

Sir FREDERICK BRAMWELL next gave evidence in favour of the scheme. He testified to the complete safety of the boring, and to the complete absence of vibration consequent on working the line.

In cross-examination, he said the proposed line would not cause as much vibration as the ordinary London traffic.

The Committee adjourned till Wednesday, at 11 a.m.

WEDNESDAY, JUNE 24TH.

Mr. RIGG, in addressing the Committee on behalf of certain lessees, owners and occupiers along the route of the proposed line, submitted that if the Bill passed in its present form any person injured by the user of the line would be shut out from compensation. This was practically the same Bill that was thrown out by a Committee of their Lordships' House last Session. It was said that the Bill of last year was rejected because the Committee were not satisfied that the railway could be worked by electricity. He was not present to dispute that the working of a railway by electricity was practicable, but he maintained that the promoters had to satisfy their Lordships not only that they could work the line but that they could make it pay. He regretted that the promoters had not thought fit to call Mr. Mott, who had had great experience of the cost of working an electrical railway, and could have given their Lordships some valuable evidence.

The CHAIRMAN asked the learned counsel whether he intended to call Mr. Mott.

Mr. RIGG replied in the negative. It was not likely, he said, that Mr. Mott would come and give evidence against his own measure. To pay a dividend of 5 per cent. on the capital of the Company it would be necessary for the Company to carry 26 millions of passengers annually. As the London General Omnibus Company, who had 'buses all over London, only carried 100 million passengers per annum, he did not think it was likely that the Central London Railway Company would carry a quarter of that number of passengers over a single line of railway. He submitted that the promoters had wholly failed to prove that they could work the line at a profit, and, therefore, he asked their Lordships to reject the Bill.

After a consultation, their Lordships announced that they considered the preamble proved.

The Bill will accordingly be reported to the House.

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LEGAL INTELLIGENCE.

Crompton and Co. v. Phillips Bros.

In the Queen's Bench Division of the High Court of Justice, on Monday, the case of Crompton and Co. *v.* Phillips came before Mr. Justice Day and a special jury. This was an action brought by Messrs. Crompton and Co., of Mansion House Buildings, electrical engineers, against Messrs. Phillips Bros., manufacturers of wire used for electric lighting purposes, carrying on business at Lea Telegraph Works, Hackney Wick, to recover £3,000 damages for an alleged breach of contract. In June, 1889, the plaintiffs required a large quantity of wire for the purpose of supplying the borough of Chelmsford with the electric light, and they ordered it of the defendants. The plaintiffs alleged that, instead of supplying them with wire of the quality and description known as C quality, braided with vulcanised rubber, of at least 0·12 thickness, in accordance with their contract, the defendants sent them wire of a much inferior quality, which was wholly useless for the purpose for which they (plaintiffs) purchased it. The defendants admitted that the thickness of the rubber was not ·12, and that they knew it was to be used by the plaintiffs at Chelmsford, but they denied that it was supplied under the contract set up by the plaintiffs, or that it was unfit for the purposes for which it was supplied. They counterclaimed for £1,405. 18s., the balance due in respect of the wire supplied.

Mr. Moulton, Q.C., and Mr. Graham appeared for the plaintiffs, while Mr. Finlay, Q.C., and Mr. Wallace represented the defendants.

Mr. CROMPTON said that in 1888 his firm undertook to supply the borough of Chelmsford with the electric light, and for that purpose they required a large quantity of insulated wire. His firm wrote to the defendants, asking the prices of their B and C quality, and they replied giving the price of C quality as follows:—No. 10, 23s. 4d.; No. 11, 21s. 3d.; No. 12, 19s. 6d.; and No. 14, 15s. 2d. His firm had purchased large quantities of B quality wire of the defendants, but they resolved to order the C quality for Chelmsford. The defendants supplied his firm with large quantities of the C quality, and about September some of it had been installed at Chelmsford. They tested the work completed, and it worked very badly indeed. At first he was indisposed to find fault with the wire, as he thought that the fault lay in the joints which his firm had made. Having found that an alteration of the joints did not improve matters, his firm tested some of the wire which was not in use, and then discovered the real fault. An inspector of the Board of Trade visited Chelmsford about this time, and his firm had to report to him that the insulation resistance of the whole of the overhead wires was not up to the standard in wet weather, though it was in dry weather. Subsequently they informed the defendants that the wires supplied was not what they had contracted for, and the defendants sent a representative to their works, who admitted that the tests showed that the wire was bad, and asked what they could expect when they purchased very cheap wire. Witness at once denied that they had purchased very cheap wire, and asserted that his firm had paid the highest price that had ever been paid for wire of the kind. The defendants' representative then said the wire was not of C quality, but was a special quality made for the plaintiff company. The insulation was absolutely rotten; he could tear the india-rubber off in short lengths. Good india-rubber vulcanised would last for 20 or 30 years. The price paid by his firm was sufficient to secure a first-rate article. When the suspicions of his firm as to the wire were confirmed they called in an independent expert to test the wire at their own works.

His LORDSHIP (to Mr. Wallace): You deny that it was of inferior quality.

Mr. WALLACE: It was good wire, and useful for a great many purposes. It was not, however, the wire which should have been used for the purpose for which the plaintiffs used it.

His LORDSHIP: You admit that the wire is of inferior quality in a certain sense—not the wire to stand the charge of electricity put into it.

Mr. WALLACE: We do not say it is inferior C quality wire; on the contrary, we say it is the best of that quality.

His LORDSHIP: Then the question for the jury is, whether the wire supplied to the defendants is what is known in the trade as C quality.

Mr. MOULTON: The plaintiffs' case is that it is rubbish, and fit for no purpose. It is not merchantable wire at all.

His LORDSHIP: The defendants must show that the wire is merchantable C wire, and that it is reasonably fit for lighting a town.

Mr. WALLACE: Mr. Crompton says it answered very well in the dry, but not in the wet.

His LORDSHIP: In our climate you must expect occasionally to have a wet day. The question for the jury is whether the wire is a merchantable wire for general purposes.

Mr. WALLACE: For such purposes as C quality is generally employed.

WITNESS, continuing, said the price paid by his firm was ample to enable the best quality of india-rubber to be used. In consequence of the condition of the wire supplied his firm called in Mr. H. R. Kempe, and sent samples to Mr. Hatton. Wire having the defects pointed out in Mr. Hatton's report was useless for electric lighting purposes. The defendants had supplied his firm with about 62,000 yards of C quality wire, and of that quantity about 54,000 yards had been actually put up. He believed that about 16,000 yards had been taken down again, and that the whole would eventually have to come down.

Cross-examined by Mr. WALLACE: None of the wire ordered was intended for inside work. He saw a sample of wire before he ordered the wire in question, and he believed the sample he saw was thicker in diameter than the piece of wire now produced by the defendants. He complained of the quality of the insulation because it was rotten and useless for any electric lighting purposes. He would swear that the sample now produced by the defendants was not shown to him before he ordered the wire in question. He did not tell the defendants for what purpose the wire was required. His firm's experience of the defendants' B quality was that it was nearly, if not quite, equal to the Chelmsford lighting. His firm had purchased B quality for house wiring. He did not know whether or not the manufacturers guaranteed any specific insulation resistance in the case of the B quality, but he believed that they did in the case of C quality. He had purchased D quality wire in small quantities for crossing docks under water. He did not remember getting a guarantee with D quality any more than he did with C quality. His firm never tested goods on delivery. His firm intended to use 2,000 volts at Chelmsford. They had not used such a high pressure before.

Mr. FINLAY, interposing, said the defendants' case was that they were not told that the wire was wanted for such a high pressure.

WITNESS in further cross-examination, said the attention of his firm was first drawn to the wire when it was found that there was no insulation at all in some wet weather. If they had only required a pressure up to 600 volts, they would have put up bare wire. The wire supplied to his firm was not C quality. In his opinion, C quality wire vulcanised was able to stand certainly test up to 1,000 megohms per mile. The india-rubber used was not good. His firm asked Prof. Jamieson, Mr. Kempe, and Mr. Hatton to test the wire.

Prof. ANDREW JAMIESON stated that he went to Messrs. Henley's works, where the samples of the wire supplied to the plaintiffs were being tested. The insulation of the wire was very bad. Mr. Hatton obtained 510 megohms per mile. In his opinion, the wire was not reasonably fit for the purpose of lighting the town with electricity. Four years ago he received from the defendants a case containing wire of different qualities, all properly marked. The wire supplied to the plaintiffs was not similar to the samples he had in his possession. The samples of C quality supplied him four years ago by the defendants were samples of a wire suitable for lighting towns with electricity. He produced his own samples of the defendants' C quality wire, as well as samples of the wire supplied by the defendants to the plaintiffs. The witness here explained to the jury the difference in the two wires.

Cross-examined by Mr. FINLAY: The india-rubber on the wire was so weak that if you pulled it it broke, and there was very little elasticity in it. In properly made C quality wire, he should expect 1,000 megohms per mile. He had not known C quality wire to be used for outside work such as that at Chelmsford.

The further hearing of the case was adjourned till Tuesday.

TUESDAY, JUNE 23RD.

Mr. H. R. KEMPE stated that he had had 18 years' experience in testing and examining insulated wires. In January, 1890, he was called in by the plaintiffs to test some wire. He tested two or three drums of wire which, apparently, had not been touched since they left the manufacturer's factory. The proper way of testing insulation was to put the wire in water, and see what the resistance was. No test would be of any value unless made in that way. In testing the wire he discovered evidences of faulty manufacture. The wire he examined was either not tinned at all, or the tinning had deteriorated. The surface of the wire had turned black. The tinning was for the purpose of preventing the sulphur acting on the copper. If it had been properly tinned the wire would not have turned black. Of the different specimens he examined, one or two showed evident traces of faulty manufacture of the insulation. In some cases the seams had opened, and in others there were cracks every few inches, through which a person could see the conducting wire beneath. It was not properly insulated wire at all. The rubber, in his opinion, was distinctly bad; it had none of the qualities of good rubber. Good rubber would stretch and return again when the extension was taken off. The rubber on the wire he examined would in every case break off short, as if it had no life in it. The wire supplied to the plaintiffs was not equal to the samples of C quality wire produced by Prof. Jamieson. It was perfectly useless as insulated wire.

Cross examined by Mr. FINLAY: He tested the wire by having the drums plunged into a tank of water. He had no recollection of wire of the description supplied to the plaintiffs being employed for outside purposes.

His LORDSHIP: What do you use in the Post Office?

WITNESS: Gutta-percha wire, as a rule—a different class of wire altogether.

In further cross-examination, witness said he had heard of this wire being used for electric lighting purposes, but he could not say it had been used out-of-doors.

Re-examined by Mr. MOULTON: If the rubber had been properly vulcanised the wire could have been used out-of-doors.

Mr. R. J. HATTON, engineer and manager of Mr. Henley's telegraph and electric light cable factory, stated that he was thoroughly acquainted with the proper method of testing cables, and had had a large experience in the business. He tested a number of samples of wire sent to him by Messrs. Crompton. The chief defects he found were cracks in the rubber, and imperfect joining of the seams. He did not know the plaintiffs' C quality wire. He had examined the samples of the defendants' C quality wire, produced by Prof. Jamieson, and found that it was a better quality wire than that supplied to the plaintiffs, because there was a drab rubber next to the wire. He had examined the wire supplied to the plaintiffs electrically, and was of opinion that it was not merchantable.

Cross-examined by Mr. FINLAY: Manufacturers of wire gave a guarantee on the point of insulation. He could get wire from 150 up to 5,000 megohms. He had given his evidence under the impression that a guarantee of 250 megohms was given by the defendants. Vulcanised wire should be tested before it was sent out. The plaintiffs had not got a cheap article. He did not think that his firm had been competing with the defendants.

Re-examined by Mr. GRAHAM: For the purpose of electric lighting he did not call the wire supplied to the plantiffs electric wire at all. It was full of holes.

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Mr. R. F. HAYWARD, electrical engineer and manager of the plaintiffs' works at Chelmsford, stated that in June, 1889, his firm wanted a large quantity of wire for lighting Chelmsford. Mr. Reed, for the defendants' representative, called at the plaintiffs' works at Chelmsford, and, in the course of a conversation, said that vulcanised wire was the best insulation that could be obtained. Witness told Mr. Reed that his firm intended to have a current of 2,400 volts, and that they had to put the wire on poles in the streets. Mr. Reed told him that vulcanised rubber would be better than pure rubber, and witness ordered C quality wire of the defendants at Mr. Crompton's request. At a subsequent interview with Mr. Reed, that gentleman produced a sample of wire about 6in. or 8in. in length, and witness looked at it but did not take much notice of it. Nothing was said as to the price of the wire on that occasion.

Cross-examined by Mr. FINLAY: He could not recollect whether Mr. Reed showed him the sample as representing the defendants' C quality. He was certain that he told Mr. Reed the wire would be used out of doors, and that the voltage would be 2,400.

Mr. ROOK, storekeeper, in the employ of the plaintiffs, gave corroborative evidence.

Mr. A. H. POTT, electrical engineer at the plaintiffs' works at Chelmsford, stated that the Chelmsford installation was left in his hands. The samples of the wire sent to the works of Mr. Henley fairly represented the bulk supplied by the defendants. He did not think the wire was a merchantable article.

Cross-examined by Mr. FINLAY: There were about 35,000 yards of wire still up at Chelmsford. With the exception of the breakdowns due to the wire the electric light had worked very well at Chelmsford. Portions of the installation gave them trouble each day in wet weather.

This closed the case for the plaintiffs.

Mr. FINLAY, in opening the case for the defendants, argued that before the plaintiffs ordered the C quality wire they knew what they would receive, and that the insulation would not be guaranteed. The defendants never guaranteed the insulation of C quality wire, though they did give a guarantee with their D quality. The wire supplied to the plaintiffs was a fair merchantable article of C quality, but the plaintiffs had not employed it properly. As a matter of fact the plaintiffs had used the wire for a purpose for which it was not intended, and had applied a much stronger current than was usually applied to such wire He maintained that the wire supplied to the plaintiffs was perfectly fit for the use to which C quality wire was universally applied.

Mr. G. R. REED, traveller in the employ of the defendants, stated that he had never seen Mr. Hayward in connection with the wire in question. The wire supplied to the plaintiffs was of C quality, braided. Some time after the wire had been supplied the plaintiffs wired for him to come down to Chelmsford. He went and saw Mr. Crompton, who told him that the wire was useless, and that it did not come up to the insulation resistance the defendants stated. Witness replied that the defendants did not guarantee the resistance, and that he, personally, had not mentioned any specific resistance. It was not the custom of the defendants to guarantee B or C quality wire. The D quality was the only wire the defendants guaranteed. The wire supplied to the plaintiffs was of good quality, and perfectly merchantable. It was the same kind of article as the defendants had been selling for a great many years.

Mr. PHILLIPS stated that he traded as Messrs. Phillips Bros., at the Lea Telegraph Works, Hackney Wick, and that he supplied A, B, C, and D quality of wire for electric purposes. They were all rubber-covered wires, but he did not guarantee any of them, except that known as D quality. He always guaranteed the resistance of his D quality to be 500 megohms. His C quality wire was used indoors for electric lighting. He had never before known of C quality wire being used out-of-doors with a current of 2,000 volts. Nobody would think of using it for 2,000 volts. He certainly should not recommend it to his customers for such a use.

Cross-examined by Mr. GRAHAM: He thought that in a dry place C quality wire was capable of standing 100 volts. He never tested his C quality wire. Some person at his place of business said the resistance of the wire supplied to the plaintiffs was 250 megohms. That was the result of the examination of a short length. The wire tested was immersed in water for a short time only. When he sold C quality wire he intended to sell a good insulated wire for electric lighting. He did not intend it to be full of cracks, though he would not guarantee that there were no cracks in it. He had a good opinion of the C quality wire. It would not be a good article if it were cracked, opened at the seams, and badly joined. He was a manufacturer of wire, but he did not make this particular wire.

Mr. W. H. MASSEY, electric lighting engineer to the Queen's household, stated that the C quality was suitable for indoor wiring of houses. He could not help thinking that the plaintiffs had made a great mistake in using it at Chelmsford. It was never intended to be so used with a current of 2,000 volts. He had compared the wire supplied to the plaintiffs with the samples of C quality produced by Prof. Jamieson, and, so far as he was able to judge, he thought that that supplied to the plaintiffs was the best, because the insulating material was thicker.

Cross-examined by Mr. GRAHAM: The C quality wire which he had used had given perfect satisfaction. He should not be surprised to hear that there were defects such as cracks in the wire supplied to the plaintiffs. If wire containing open cracks were supplied to him he should not put it up, but reject it there and then. The C quality wire was not suitable for out-of-door electric lighting, but it might do where the voltage was low. If, however, the voltage was at all high, he should not use it out of-doors, except in a dry climate.

Mr. W. B. ESSON stated that he had inspected the coils of wire produced by the plaintiffs as specimens of the wire supplied by the defendants for the Chelmsford work. They appeared to be a fair quality of vulcanised rubber. The wire was suitable for indoor use up to 100 volts.

Cross-examined by Mr. GRAHAM: The insulation was not high enough for the wire to be used out-of-doors.

WILLIAM STORR, foreman, in the employ of Messrs. Johnson and Phillips, wire manufacturers, stated that his employers made C quality wire for the defendants. He saw the whole of the wire supplied to the plaintiffs manufactured. It was good, merchantable C quality wire. The copper, tinning, and rubber were all good.

This concluded the evidence for the defendants.

Mr. FINLAY, in summing up the case for the defendants, said the main issue was whether the plaintiffs were entitled to complain that the defendants had supplied them with a wire which had not the insulation they required. He submitted that the defendants had supplied the plaintiffs with the wire they ordered, and that it would be unfair to call upon them to pay damages because the wire would not answer the purposes for which the plaintiffs had thought fit to use it.

Mr. GRAHAM, on behalf of the plaintiffs, maintained that the evidence bore out the plaintiffs' case that the wire was not according to contract, and that it was unfit for the purposes for which it was supplied.

His LORDSHIP, in summing up the whole case, said the witnesses agreed upon the point that it was no good using C quality wire for such a purpose in this country. Had the plaintiffs satisfied them that the defendants had not supplied wire in accordance with the terms of the contract? If they failed they had brought the mischief on themselves, because if by ordering C quality they intended to have a wire to be used out-of-doors, they should have asked for a guarantee as to the insulation.

The jury found a verdict for the plaintiffs, and it was decided that the amount of damages should be assessed by Mr. Kempe and Mr. Massey.

The defendants gave notice of appeal, and execution was stayed.

Lovering v. City of London and Southwark Subway Company.

This was an appeal before the Master of the Rolls, Lord Justice Bowen, and Lord Justice Kay, by the plaintiff from the judgment of Mr. Justice Lawrance. The plaintiff claimed against the defendant Company as mortgagee in possession of Nos. 44 and 45, King William-street, and 6, Arthur-street, in the City, which she alleged had been injuriously affected by cracking and subsidence in consequence of the defendants' use of their statutory powers. Both parties appointed an arbitrator, and the claim was referred to arbitration, and an award of £1,700 was made. The present action was brought on the award, but Mr. Justice Lawrance gave judgment for the defendants, on the ground that, as most of the premises were underlet and the tenants were paying rent to the plaintiff, she was not mortgagee in possession, but only had a reversionary interest in the premises, and that as the under-leases by the plaintiff were not disclosed by the claim, her claim was misleading, and she was not entitled to succeed. The plaintiff appealed.

Mr. Finlay, Q.C., and Mr. A. J. David were for the plaintiff; and Mr. Wheeler, Q.C., and Mr. William Graham for the defendants.

The Court allowed the appeal.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *June* 13, 1891.

Patent Litigation.—The present time seems to be a period of especially vicious patent litigation. In addition to the Edison-Westinghouse suit that has just been concluded, and is now awaiting decision, the infringement case between Mr. Brush and the Electric Accumulator Company is up for argument before Judge Cox. It is on this suit more than any other that the rights to the accumulator in this country depend. Last year the suit between the Brush and Julien Companies was decided in favour of the former, but the litigation was not altogether satisfactory, because of arrangements for licences that had been made before the decision was rendered. Several issues of considerable importance were left untouched, and have been taken up in the course of the present suit. Chief among these are the questions relating to the Brush Italian patent, which may serve to invalidate the American one. But this is not all, for the Edison General Electric Company has brought suit virtually against the Thomson-Houston Company, although nominally against the West End Railway Company of Boston, on the fundamental questions of street railway work. The complainant is suing under the Sprague patents that are claimed to cover the field of electric traction. The Thomson-Houston Company owns the Van-Depoele and Bently-Knight patents. As side issues in this suit the rights of Henry, Daft, Field, Adams, and some other pioneers of electric railroad work will be involved. The merits of the case are by no means easy to determine. If the Edison Company should win the suits, we should be treated to a session of litigation with other companies that use virtually the same appliances. As in the invention of the incandescent lamp, a considerable number of men and many patents are involved in this electrical traction issue, and, as in the incandescent lamp suit, too, the suits wi probably turn on the state of

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the art at the time the patents in litigation were issued. It will probably require several years to reach even a preliminary decision unless the legal proceedings are very much more rapid than they generally are.

Hostility to Electric Traction at Brooklyn.—*Apropos* of electric railroads, the City of Brooklyn is now the scene of a very acrimonious discussion of the trolley system. Several of the street railway companies secured the necessary consents of property owners for the proposed change in motive power, but when the requisite permits from the authorities were applied for it was found that some hostile element had very carefully and thoroughly aroused public sentiment against the road by the customary chain of malicious falsehoods concerning the dangers of overhead wires. Some of the frightened property holders withdrew their consents that had previously been given, and most determined opposition is being made to anything that looks towards electric traction. It is very difficult to understand the real source of this and to find out what interests are so much involved as to induce the necessarily great expense of the litigations that will follow.

Rapid Transit in New York.—In New York the rapid transit situation remains unchanged. The engineers of the Board of Rapid Transit Commissioners are at work drawing up plans that will be presented to the public later; but it is hardly to be expected that anything definite will be announced before the middle of July. The elevated railroad interests are very active in objecting to the underground road, as they have plans of their own that will be seriously interfered with or rendered impossible by any such innovation. They are, however, in such peculiarly bad odour with the public that the favours extended to them will be few and small.

State of the Electrical Industry.—The electrical business in general appears to be flourishing more than is usual for this season of the year. The principal companies all report large orders, and construction work is in active progress all over the country. Among the items of news that are going the rounds at present one may be particularly mentioned; it is expected that within a short time the Edison Company will appear in the field with an alternating current system. This is generally understood to be a concession to the popular demand, for Mr. Edison himself has been persistently and consistently opposed to its introduction. Experiments on the subject have been in progress in the Edison laboratory for a long time, and, besides having Mr. Kennelly at work, the services of Thorburn Reid, an engineer well known in alternating current circles, have been secured. It is hardly probable that any striking innovations in alternating current practice will be attempted, however.

SCANDINAVIAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

COPENHAGEN, *June* 20, 1891.

The Elektriska Aktiebolaget, Stockholm, last year carried out 29 new electric light installations, in addition to which several older ones have been extended. The work done comprises the supply of 22 dynamos, 53 arc lamps, and 4,800 incandescent lamps, besides accumulators. For power transmission, &c., the Company had further supplied 14 dynamos of 227 electric H.P. The Company has, since its formation, supplied 217 dynamos of 2,715 electric H.P., about 22,200 incandescent lamps, and about 90 arc lamps. The Elektriska Aktiebolaget has now amalgamated with the Allmäune Svenska Elektriska Bolaget.

The contract for the municipal central lighting station at Stockholm has been obtained by Siemens and Halske, of Berlin, and the works are to be ready for use by December 1st of the present year. This well-known Berlin firm has to supply two 210 kilowatt dynamos, 280 Tudor accumulators, with an aggregate capacity of 2,500 ampere hours, and all requisite appliances and apparatus; also underground cables for 10,000 simultaneously burning lamps. The dynamos will be coupled direct to their respective engines. Babcock and Wilcox boilers will be used, and the engines are to be supplied by the Lindberg Engineering Works. There are already a good many Siemens and Halske installations in Scandinavia, and this firm has, no doubt, done more work in this country than any other. There is already a fair amount of electric lighting in Stockholm: about a twelvemonth ago there were some 15,000 incandescent lamps and 250 arc lamps.

Both in Christiania and here in Copenhagen the central stations have received considerably more applications for light than had been reckoned upon. In Christiania the first applications amounted to more than 4,000 incandescent lamps, and about 80 arc lamps, although this number was not expected to be reached till the second year. The applicants comprise the Houses of Parliament, the University, the principal hotels, &c. The new Masonic Lodge is the largest consumer, over 600 incandescent lamps and 4 arc lamps. Several applications have also been received for electricity for motive power.

The Stockholm General Telephone Company is indefatigable in its endeavours to accommodate its customers, present and future, and I doubt whether any telephone company boasts a better all-round management than this large concern. The latest move is a telephone for an annual subscription of 10kr. (11s.); for this sum the Company will install a telephone in any house, subject to the user paying 10 öre (1½d.) per telephonic conversation, that is, for any telephonic message the subscriber *sends*; he may *receive* as many as he likes free of any charge. There is an automatic appliance for registering the number of conversations. Separate exchanges will be erected for these 10kr. telephones, and Stockholm will, as far as they are concerned, be divided into 14 districts, each with its exchange; these are to be connected with each other and with the main central exchange. The first of these exchanges will be ready to commence work on October 1st. Stockholm has already the largest number of telephones per hundred inhabitants of any city in the world? What will this percentage grow into when the telephone, by this new arrangement, is brought within the reach of almost everybody?

The Swedish State telephones are also being pushed in all directions with much energy, and Sweden will, ere long, be one complete net of telephones. The last Parliamentary vote was 1,000,000kr., which will be used for extensions in various places, for the purchase of a further number of private telephone companies, &c. In October a grant was made of 600,000kr., which has already been expended some months ago. By the purchases and new installations effected through the means of this latter sum, the number of telephones within the State system was increased from 3,800 to 5,500, an increase representing 45 per cent, resulting in a calculated increase in gross receipts from 364,000kr. to 550,000kr. annually, or about 51 per cent. The 1,000,000kr. are intended for the purchase of the Norrköping, the Nyköping, the Linköping, the Jönköping, the Vexiö, the Örebro, the Köping, and the Söderhaum telephone concerns, which are expected to cost 470,000kr., in addition to which their connection with the State telephone system will entail an outlay of a further 160,000kr. The above telephone companies will bring another 2,000 telephones to the State telephones, and an increase in receipts of 150.000kr. annually, apart from the increase in subscribers, which may safely be calculated upon. There are, however, many applications from different parts of the country, through which, or close to which, the State telephones pass, that they may be brought within the State telephone system, and many of these applications can also be complied with at a comparatively small cost. It is at present under consideration to connect Malmö with Copenhagen by a submarine telephone, some 18 miles long, which would bring Stockholm and Copenhagen in direct telephonic connection. By a telephone from Örebro to Magnor, and from there to Christiania, this latter town will also be in direct telephonic communication with Stockholm.

CORRESPONDENCE.

THE CHEMISTRY OF THE SECONDARY CELL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you kindly allow me to amend a somewhat misleading remark in the "Retrospect" on the Chemistry of the Secondary Cell, contributed by Mr. Robertson to your issue of June 12th?

In referring to two Papers by Dr. Gladstone and myself, Mr. Robertson rightly says we discovered no ground for supposing that the substance formed by the action of dilute sulphuric acid on litharge or minium respectively to be other than a mixture, and then remarks:—"But as they made use of analysis, their work is open to the objection that they may have destroyed the compound."

I want to point out that this objection cannot apply at all to the method followed in the first of our two Papers—that is,

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the one dealing with the action of sulphuric acid on litharge. We did not analyse the bodies described by Dr. Frankland. Our method was to add a known excess of acid to a known quantity of litharge, and to study the rate and amount of change each day by determining how much SO_4 had been abstracted from the liquid. This involved no disturbance of the oxysulphate, and yet it told us the composition of the body at any stage of the action.

Curves given in the Paper show the rate of chemical change to a stage much beyond that required by Dr. Frankland's formula.—Yours, &c., W. HIBBERT.

14, Goldhurst-terrace East, South Hampstead, N.W.,
June 22, 1891.

THE NEW PERRY METER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have seen in your last issue the description of Prof. Perry's new meter, and take the earliest opportunity of stating that I consider it in several essential points an infringement of my patents.—Yours, &c.,

Birmingham, June 23, 1891. GEORGE HOOKHAM.

THE WADDELL-ENTZ ACCUMULATOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We were very glad to notice in your issue of May 22nd a description of our Accumulator and Motor.

We regret that, in mentioning the names of the inventors, your correspondent omitted the name of Mr. William A. Phillips, formerly of the firm of Phillips Brothers. Mr. Phillips has been for some years connected with the Edison Company, and is now devoting all his attention to the development of this battery, of which he is one of the inventors. Mr. Phillips is a brother of Mr. Phillips of the firm of Johnson and Phillips.

The results already obtained have been eminently satisfactory, and each day confirms us in our opinion of the practical nature and durability of this battery.—Yours, &c.,

J. A. MACHADO, Sec.

The Waddell-Entz Electric Co., New York, June 16, 1891.

THE ROYAL AGRICULTURAL SOCIETY'S SHOW.

The Royal Agricultural Society of England held their fifty-second annual exhibition during the present week, at Doncaster. There was a very fine display of agricultural machinery and implements, but the only exhibits of interest to our readers are the engines, which have always been a feature at these shows, and which owe a great deal to the elaborate scientific tests which used to be made some ten years ago by the engineers of the Society.

Amongst the leading exhibitors were Messrs. Robey and Co., Messrs. Francis Morton and Co., Messrs. W. H. Willcox and Co., Messrs. W. F. Dennis and Co., the Pulsometer Engineering Company, Mr. E. S. Hindley, the Blackman Ventilating Company, Messrs. Marshall, Sons, and Co., Messrs. Priestman Brothers (Limited), Messrs. Crossley Brothers (Limited), Messrs. Ransomes, Sims, and Jefferies (Limited), and Messrs. Davey, Paxman and Co.

Included in the exhibit of Messrs. ROBEY and Co. were several of their well-known portable, compound, high-speed, vertical, and horizontal fixed engines up to 8 H.P., including a high-speed vertical engine, with 6½in. cylinder and 6in. stroke, suitable for small electric light installations, ship lighting, &c.

The PULSOMETER ENGINEERING COMPANY had on view a large Patent "Deane" Pump, capable of discharging 40,000 gallons of water per hour, and a number of Pulsometer Patent Steam Pumps. There were also on view samples of the Company's various sizes of pumps, and photographs showing many forms of application. This Company's manufactures are well known to many of our readers, and quite a number of Pulsometer and Deane pumps are in use in central stations in this country and abroad. One of the largest size Pulsometers (No. 11½) was on show, suspended as used for well and shaft sinking.

Mr. E. S. HINDLEY exhibited several horizontal and vertical engines, a 3 H.P. hoisting engine, saw benches, donkey pumps, &c. Included in this exhibit was a 4 H.P. vertical engine and boiler on wheels.

Messrs. MARSHALL, SONS, and Co. had a fine exhibit, and amongst the engines shown were a high-pressure horizontal steam engine, fitted with Proell's patent automatic expansion gear; a new horizontal and a vertical engine, both of which are specially adapted for electric light and other machinery requiring steady running. Included in this firm's exhibit are a number of traction engines of Messrs. Marshall's well-known types.

Messrs. PRIESTMAN BROTHERS had on show four different specimens of oil engines (Priestman and Hume's patent): a 2 H.P. horizontal, a 5 H.P. vertical, an 11 H.P. portable, and an 18 H.P. horizontal, the latter fitted with oil cistern, vaporiser, air pump, igniting apparatus, and all details required for the preparation of oil vapour.

Messrs. CROSSLEY BROTHERS had on view six of their well-known gas engines, including a newly-designed high speed engine known as the "E" size, specially arranged to run at 250 revolutions and to give 9 H.P. effective on the belt. Messrs. Crossley Brothers guarantee absolute steadiness with this engine driving direct on the dynamo, and claim that it is unnecessary to fit the dynamo with a fly-wheel or disc. The other engines shown in this firm's exhibit range from a ½ H.P. vertical to a 14 H.P. horizontal, and all these engines are fitted up with the latest improvements—the 14 H.P. being capable of indicating 33 H.P.

Messrs. RANSOMES, SIMS, and JEFFERIES had two very fine exhibits, including their celebrated ploughs, lawn mowers, threshing machines, stacking machines, &c. Amongst the engines shown by this firm was a 10 H.P. compound "new type" engine, fitted with patent automatic governor expansion gear, specially suited for driving electric light machinery.

Messrs. DAVEY, PAXMAN and Co. exhibited one of their compound portable engines and a single cylinder portable engine, which were again selected by the Royal Society for carrying out the trials of the threshing machines. The compound engine is of the "Receiver" type, the cranes being at right angles. The two cylinders are made in one casting, and each cylinder is jacketed, the jacket being formed by forcing a truly turned and bored liner into the outer cylinder. The high-pressure cylinder is fitted with Paxman's patent automatic expansion gear, worked direct by Paxman's patent adjustable high-speed governor. The engine is practically independent of the boiler, so that for high pressures the boiler can be relieved from all undue strains. An efficient feed-water heater is provided. The boiler is of the locomotive type, with flush top. The fire-box is made of specially mild ductile steel, which is expressly manufactured for Davey, Paxman and Co. Messrs. Davey, Paxman and Co. inform us that they have for many years used this steel for fire-boxes, and the results have been most satisfactory. In addition, this firm had on show several examples of their horizontal, vertical, portable, and semi-fixed engines, one of which was shown driving a Marsden stone breaker.

Amongst the miscellaneous exhibitors, Messrs. FRANCIS MORTON and Co. had a fine show of their well-known manufactures; Messrs. W. H. WILLCOX and Co. exhibited a large quantity of engineers' stores, &c.; Messrs. W. F. DENNIS and Co. showed a quantity of specially galvanised steel barbed wire, manufactured by Messrs. FELTEN and GUILLEAUME, for whom Messrs. Dennis and Co. are the British agents; and the BLACKMAN VENTILATING COMPANY were to the front with their well-known fans, several of which were in operation, driven by one of Messrs. F. Ashwell and Co.'s steam engines. Included in this exhibit were fans varying from 24in. to 54in. diameter.

We have again to note the almost entire absence of anything electrical at this exhibition of the Royal Agricultural Society.

BOOKS, &c., RECEIVED.

"Patents for Inventions, and how to procure them." By G. G. M. Hardingham. (London: Crosby Lockwood and Son.)

"Dynamo Construction." By John W. Urquhart. (London: Crosby Lockwood and Son.)

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TRADE NOTES AND NOTICES.

[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.]

NOW READY.—"THE ELECTRICIAN" PRIMERS (38 in all), in two volumes. Price per volume 2s. paper covers, 2s. 6d. cloth; post free, 2s. 2d. and 2s. 9d. respectively. Single copies, 3d.; post free, 3½d. Prospectus on application to the Publisher.

TENDERS INVITED.—The Local Board for the District of Carshalton invite tenders for the lighting of their district, which consists of the entire area of the parish of Carshalton, with gas, oil, or other illuminant, for a period of 12 months from July 31, 1891. Tenders, addressed to the Chairman of the Board, must be deposited at the Board offices, High-street, Carshalton, by 12 noon on July 8, 1891.

——— The Cleethorpes-with-Thrunscoe Urban Sanitary Authority want tenders for lighting the streets and highways within their district with gas or by any other means, for one year, from July 23rd next. Tenders are to be sent to the Chairman of the Board by July 1st.

RESULT OF TENDERS.—Messrs. J. H. Holmes and Co., of Newcastle-on-Tyne, have secured the contract for lighting with electricity the Town Hall of Cleckheaton.

SALES BY AUCTION.—We would remind our readers that the sale of the stock, plant, and machinery of the Electrical Engineering Corporation, Limited (in liquidation), takes place Tuesday next and the following days, at the Alliance Engineering Works, at West Drayton, near the West Drayton station on the Great Western line. Included in the sale is a quantity of steel wire rope and cables, arc lamps, shades, carbon, fuses, mica, dynamos of various outputs, sheet fibre, bolts, nuts, nails, screws, and general electrical engineering stores, portable compound and vertical engines, boilers, planing machines, drilling machines, about 250 tons of iron castings, 10 tons of copper wire, saw benches, vices, forges, pumps, a complete foundry plant, designs, shop drawings, and patterns of vertical high-speed engines and modern dynamos, and included in the sale are eight Telpher passenger cars. The whole stock, plant, and machinery will be on view for two days prior to the sale. Catalogues may be obtained of Mr. F. W. Pixley, 24, Moorgate-street, E.C.; of Messrs. Dowson, Ainsley, and Martineau, 28, Bedford-row, W.C.; and of the Auctioneers, Messrs. Hobson, Richards, and Co., of 79, Coleman-street, E.C. A special fast train leaves Paddington station (main line) at 11:5, arriving at West Drayton at 11:35, on the mornings of the sale.

———Messrs. Wheatley Kirk, Price, and Goulty announce in our advertisement columns that the business known as Quintin Matsys Forge, 14, Griffin-street, York-road, Lambeth, will be sold by auction early in July, unless previously disposed of by private treaty.

PLANT FOR SALE.—The Pilsen Electric Company notify in our advertisement columns that they have for sale a large quantity of dynamos and arc lamps, a 40 H.P. undertype compound engine, a 25 H.P. and a 12 H.P. undertype high-pressure double-cylinder engine, and a quantity of shafting, standards, and belting.

THE TAUNTON ELECTRICAL ENGINEERING EXHIBITION.—Mr. H. C. Willson, manager and secretary of this Exhibition, notifies that firms requiring space in the Exhibition must apply at once, as the last day for receiving entries is the 30th instant. The printers of the official catalogue are Messrs. Goodman and Sons, of Taunton, with whom intending advertisers are requested to communicate.

MATHER AND PLATT'S DYNAMO CATALOGUE.—The fourth edition of the catalogue relating to the Edison-Hopkinson dynamos and motors contains a good deal of information as to the efficiencies and durability of the high class electrical machinery built by this firm. Having a very important general engineering business, of which the electrical department is only a branch, Messrs. Mather and Platt have done well in declining to compete with other manufacturers by attempting to build dynamos which give a large output for their weight and price. By providing very heavy fields, and by refraining from overloading any part, they are enabled to point to the highest efficiencies that have yet been recorded.

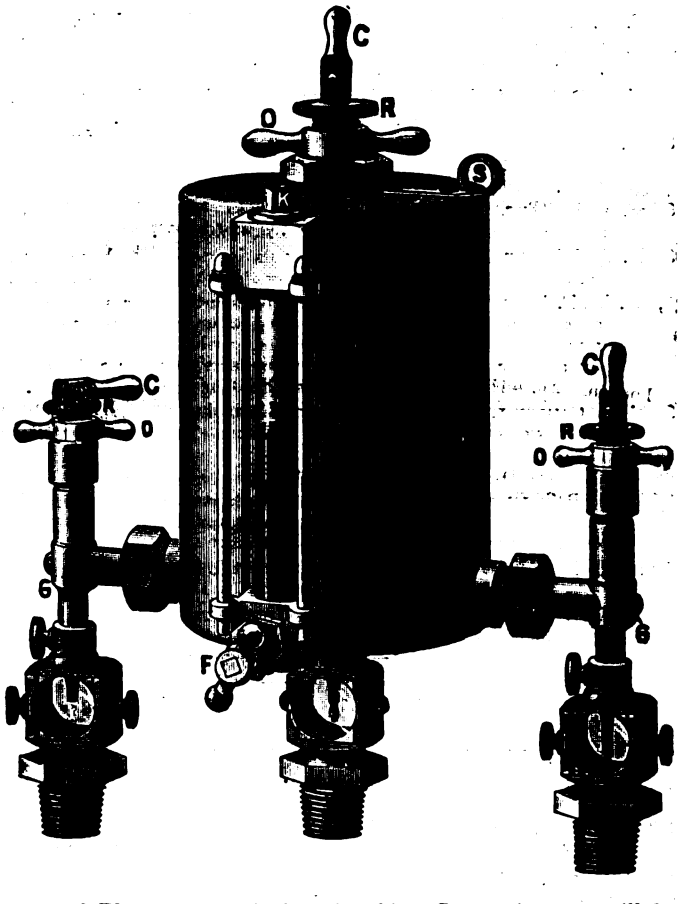
MESSRS. RASHLEIGH PHIPPS AND DAWSON.—At a *conversazione* of the Royal Medical and Chirurgical Society, on the 23rd inst., at which nearly 2,000 of the leading doctors of the United Kingdom were present this firm gave an interesting exhibit of electrical and other appliances, these including:—A small incandescent lamp for examination of mouth and teeth, and looking right down throat; an electro-magnet for removing fragments from the eye; an electric dental drill; an incandescent lamp, with holder for microscope; physicians', practitioners', and patients' batteries; a Cantery battery, with rheostat-canteres and handles; a new form of photophore battery; a lantern worked by 100 c.p. incandescent lamp, throwing many interesting medical subjects on to a large screen; new patent speaking tubes, &c. The rooms were lighted by the electric light installed by the firm, the whole being very effective.

KIRKALDY'S AUXILIARY SURFACE CONDENSERS AND FEED-WATER HEATERS.—We would call the attention of electrical engineers to the display of auxiliary surface condensers and feed-water heaters, made by Messrs. John Kirkaldy (Limited), in the Machinery Hall at the Royal Naval Exhibition. These condensers and feed-water heaters are well worth inspection, as they are both of economic value and of interest to electricians in connection with electric lighting installations.

PROTEAN BATTERY SYNDICATE (LIMITED).—Resolutions were passed at a meeting on May 8th, and confirmed at a meeting on May 29th, that the Syndicate be wound up, and that Mr. John Bidden, 63, Plumpstead-common-road, Woolwich, be the liquidator.

SCIENTIFIC ALLIANCE.—Under the above title, at Nos. 7 and 8, Dyer's-buildings, Holborn, E.C., Mr. H. Dale Vallon has commenced a manufactory for small electric fittings, apparatus for inventors, &c.

POWELL'S TRIPLE SIGHT-FEED LUBRICATOR.—A large lubricator for long dynamo bearings is made by the Wm. Powell Company, of Plum-street, Cincinnati, Ohio. It consists, as will be seen in the illustration, of a reservoir A, holding from one quart to one gallon. It is provided with a gauge glass J. A valve F is provided for cutting off the connection, in case the gauge glass is broken, when a new glass can be fitted by removing the screw K. The three feeders are each provided with a screw collar, R, for adjusting the feed, and this when set to give the desired flow is clamped by the lock nut O. The lubricant can be turned on or off, without affecting the adjustment, by the "signal lever" C. The sight feed is arranged with square glass covers, which may be easily removed for cleaning, and can readily be replaced if broken. This method of separate adjustment and cut off, together with a sight feed, is an excellent one, and for large bearings this triple lubricator should be very useful.



ELECTRIC CONSTRUCTION CORPORATION.—This Corporation informs us that arrangements have been made with the Foreign and Colonial Electrical Power Storage Company, by which their storage battery business at home, as well as abroad, has been transferred to the latter Company. The manufacture of E.P.S. batteries will be continued at the Milwall Works, as heretofore, under the superintendence of Mr. Frank King, who has been so long associated with their development. All orders and correspondence in reference to future business should be addressed to the Secretary, 4, Great Winchester-street, London, E.C.

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PATENT RECORD.

APPLICATIONS FOR PATENTS.

May 25, 1891.

8,830. J. A. KINGDON. London. Improvements in the regulation and control of electric currents, particularly applicable to transformers, and in apparatus therefor.

8,845. R. HADDAN. London. Improvements in galvanic batteries. (J. Cabanyes, France).

May 26, 1891.

8,872. J. F. BENNETT and E. P. HIDES. Sheffield. Improvements in galvanic batteries.

8,873. J. F. BENNETT and E. P. HIDES. Sheffield. Improvements in the construction of telephones, electric bells and parts relating thereto.

8,874. J. F. BENNETT and E. P. HIDES. Sheffield. Improvements in telephones and electric bells.

8,876. A. HOSTER. London. Improvements for recording or registering the time during which an electric current is in circuit.

8,892. J. H. ADAMS. London. Improvements in dynamos.

8,896. R. BOLTON. London. Improvements in means or apparatus for regulating or controlling the operation of machinery by electromotive power.

8,922. H. S. PRENTISS. London. Improvements in electric clocks.

8,924. H. H. LAKE. London. Improvements in fuse blocks for electric circuits. (H. S. Haliske, United States).

8,925. C. R. BONNÉ. London. Improvements in electric clocks, watches, or timepieces. (The Société d'Horlogerie, Switzerland).

8,927. W. PAYNE-GALLWEY, W. S. RAWSON, and WOODHOUSE and RAWSON UNITED (LIMITED). London. Improvements in electro-magnetic tools.

8,932. H. H. LAKE. London. Improvements in electric locomotives or street car motors. (R. Eickemeyer, United States).

8,941. A. J. BOULT. London. Improvements in method and apparatus for electrical hardening and tempering. (E. E. Ries, United States).

8,942. W. P. THOMPSON. Liverpool. Improvements in or relating to automatically and electrically stopping railway trains when within a predetermined distance of each other, or when the line is blocked by another train, or it is otherwise dangerous for a train to proceed, and in apparatus therefor. (E. Deming, United States).

8,961. A. CAMPBELL. London. An improved method of measuring electrical currents by expansion of fluid contained in hollow conductors heated by the currents.

May 27 1891

8,963. W. B. SISLING, W. H. SCOTT, and LAURENCE, SCOTT and Co. Norwich. Improvements in the method of wiring for electric lighting and other purposes.

8,991. G. BISHOP. London. An improved electric fire-alarm.

May 28, 1891.

9,029 W. A. TURBAYNE. Manchester. Improvements in electric arc lamps.

SPECIFICATIONS PUBLISHED.

1890.

7 219. PERRY. Electric supply meter. (Price 8d.)

7,540. WISE (LA SOCIÉTÉ JAPY FRÈRES ET CIE.) Electric arc lamps (Price 8d.)

8,394. WRIGHT. Primary batteries. (Price 6d.)

9,130. HEAP and SHARP. Regulating electric currents. (Price 8d.)

9,257. WOHLE. Electrolytic deposit with aluminium. (Price 4d.)

9,276. WILLIAMS. Driving dynamos. Price 4d.

9,411. FITZSIMON. Telephone plug. (Price 6d.)

9,904. CLARKE. Electrical armatures. (Price 8d.)

10,187. THOMPSON. (Stanley and another). Electric generators. (Price 8d.)

10,252. BAYLY (Evans.) Electric railways. (Price 8d.)

10,316. ANDREWS. Electric safety fuses. (Price 6d.)

1891.

248. CORNING. Transferring electric car batteries. (Price 8d.)

860. BAGNOLD. Electric bell repeater. (Price 6d.)

1,969. LAKE (Burrell). Electrical signalling apparatus. (Price 8d.)

1,987. CLARK (Easton). Electric lamps. (Price 8d.)

2,334. EYRE and GRAHAM. Electrical communicators for vehicles, &c. (Price 6d.)

3,331. CURRIE. Secondary batteries. (Price 8d.)

3,357. LAKE (Berrenberg). Vacuum pumps for exhausting incandescent electric lamps. (Price 6d.)

3,449. RABRIDGE. Telephones. (Price 6d.)

3,799. CLARKE. Charging electric batteries. (Price 4d.)

3,895. CORNING. Transferring electric car batteries. (Price 8d.)

4,259. LAKE (The Giant Electric Motor Company). Electric motors. (Price 6d.)

4,263. WRIGHT and WILSON. Telephones. (Price 8d.)

4,792. SILKMAN. Electric type writers. (Price 1s. 1d.)

COMPANIES' MEETINGS & REPORTS.

House to House Electric Supply Company (Limited).

The third ordinary general meeting of the Company was held last Friday, at the Company's Central Station, Richmond-road, Kensington; the Chairman, Mr. Henry Ramié Beeton.

The SECRETARY (Mr. H. St. John Winkworth) having read the notice calling the meeting,

The CHAIRMAN said: Gentlemen, the report that is in the hands of the shareholders, dealing with the accounts relating to the year 189', refers to the progress of the Company up to the date of its issue, which is approximately 12 months later than the report which dealt with the accounts for the period ending December 31, 1889. From the statements contained therein it appears that the Company has made steady progress during the period under review, although that progress has not been quite so rapid as might have been predicted from that previously experienced. This is partly due to the system of mains having been extended less during the 12 months in question. The result, although it is in strict accordance with the anticipations which I ventured to make on the last occasion when I addressed the shareholders, has been somewhat prejudiced by the increased price of coal, which has, I suppose, averaged 20 per cent. more. You will notice from the chart exhibited on the wall that our growth from the commencement has been steady and continuous, but the revenue account of the Company for the year 1890 relates, of course, to an average demand, and it will be seen from the present report that the number of lamps now connected is upwards of 16,000, as against 7,000 twelve months ago! It is fair to assume, therefore, that the returns for the year 1891 will be based upon an average demand for the 12 months from a number of lamps equivalent to that at present connected in our district. We have been able during this period to effect several economies in working; we have closed our City office entirely; we have dispensed with the draftsmen and canvassers at Kensington; we have reduced our establishment expenses; and we have handed over our installation business to a fittings company on advantageous terms. This introduction of economies will result in the diminution of expenditure to the extent of probably about £1,000 a year; but the full benefit of that economy is not apparent in the balance-sheet now before the shareholders. We see our way to further savings in regard to the water supply and improved appliances, but these can only result from a capital expenditure which we have not felt justified up to the present time in incurring, but which we hope shortly to do. This being the case, I think that the anticipation which I ventured upon last year, that we should now be in the enjoyment of a demand which would ensure us a fair dividend, will be substantiated by the result. I look forward with confidence to a prosperous future for the undertaking. I regret that I am not in a position to announce any definite progress with regard to the disposal of our construction asset, but the matter has continued to receive the attention of the Directors, and we hope that the negotiations now in progress are likely to be soon consummated with satisfactory results. With these observations, I beg to move—

"*That the report and accounts for the year ended December 31, 1890, be received and adopted.*"

The MANAGING DIRECTOR (Mr. Robert Hammond) seconded the motion.

The CHAIRMAN, in reply to Mr. VAN LAUN, said that, notwithstanding all the drawbacks incidental to the establishment of an enterprise such as theirs, the original statements made to the shareholders by the Board had been substantiated, for on the basis of the present demand they would earn a good profit. They had been careful to draw the attention of the shareholders to the fact that the requirements of the Company demanded necessarily additional capital, and if they were to do justice to their district that capital must be found.

The MANAGING DIRECTOR, in further reply to the same gentleman, said that the Company held Parliamentary powers for 42 years on terms which were exceedingly favourable—terms which were obtained by the early London companies which were not being obtained now by applicants for Provisional Orders from the country. They had a business, therefore, with a long Parliamentary tenure, and that business was every day improving. He was quite certain that a searching examination of the accounts would convince anyone that there was no fear of its ever retrograding. Their works had been visited by people from all parts of the country, and were acknowledged by everyone technically versed in such matters to be the finest extant for electrical distribution. He added that, pending the building up of the Company's business, the Directors had decided to forego their claims to Directors' fees.

The motion was then agreed to *nem. con.*

The CHAIRMAN next moved, and Mr. HAMMOND seconded, the re-election of the retiring Directors, Mr. W. Page and Mr. R. A. Germainò, which was also agreed to unanimously.

On the motion of Mr. WHITEHEAD, seconded by Mr. BEEVOR, the auditors, Messrs. Theobald Bros. and Miall, were reappointed, and the proceedings terminated with a vote of thanks to the Chairman.

A. U. Alcock Electric Light and Motive Power Company, Limited, (Melbourne, Australia).

The third half-yearly meeting of this Company was held at Melbourne, Victoria, on Wednesday, April 29th, Mr. W. J. Mountain, Chairman of the Board of Directors, presiding.

The report and balance-sheet, which had been previously circulated amongst the shareholders, were taken as read. The Directors, in the

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report, congratulated the shareholders on the satisfactory result of the past half-year's proceedings. The profits amounted to £490. 2s. 8d., which, considering the excessive cost of fuel during the late strike, and the fact that the price of lighting was not raised to their consumers, must be a cause of satisfaction. Due allowance had been made for depreciation of plant, and, after providing for one-fifth of the balance of the expenses incidental to the formation of the Company, there was a credit balance of £678. 8s. 7d. to the profit and loss account, which the Directors recommended should be carried forward to next half-year. The profit and loss account did not include the charge for interest. It had been considered that, as the overdraft was caused by the erection of the building and the purchase of the machinery, the amount charged by the bank for interest while the building and plant were in progress, should be charged to those respective accounts. A third issue of 15,000 shares had been made to complete the buildings and machinery of the central station at Richmond, of which 7,000 had been taken by the shareholders, and the Directors were confident of being able to dispose of the balance of 8,000 to the public. The machinery for supplying the incandescent light in South Melbourne was started on April 11th, and promised to be a great success. The Company had obtained "the exclusive right for Victoria to a meter that had just been invented;" and the Directors, in conclusion, considered the prospects of the Company as most assuring.

The CHAIRMAN, in moving the adoption of the report and balance-sheet, congratulated the shareholders on the favourable results which had attended the Company. The plant at present in use was only small, and the returns were very favourable for the size of the machinery, considering that £200 extra had to be paid for fuel in consequence of the late strike. Although the Company had only been in existence 18 months, the Directors considered themselves thoroughly justified in launching out on a much larger scale, so as to be able to supply Melbourne and the suburbs. They had therefore purchased a large block of land at Richmond on which they had erected a section of a central station. From its position the central station was most easy of access from Melbourne and surrounding cities and suburbs, of which the Company anticipated lighting a considerable proportion. The Company had also secured the patent of a meter which, in every respect, had proved satisfactory. Instead of selling their electricity by contract they would be able to sell it to their customers by meter, and the consumers would only have to pay for just what they consumed. There was an increased demand for the Company's light, and the Company would have no difficulty in supplying all the demands that could be made upon them. The Company were also moving in the direction of trying to obtain an Act of Parliament which would legalise them as a company, and confer advanced rights on them and on their consumers. There was a very influential directory of the Company, and they took the greatest interest in furthering its progress.

Mr. C. FLESCH seconded the motion, and it was carried unanimously.

Messrs. C. M. Holmes and W. Cook were re-elected auditors, and a vote of thanks was passed to the Directors for their past services.

West African Telegraph Company (Limited).

The following is the report of the Directors of this Company to the sixth ordinary general meeting of shareholders, to be held at Winchester House, E.C., on Thursday, July 2nd, at 12:30 o'clock.

The Company's revenue for the 12 months ended December 31, 1890, amounted to £68,377. 19s.; against which £21,685. 13s. 7d. is charged for ordinary expenses £4,788. 14s. 3d., for expenditure relating to repairs of cables, &c., and £639. 8s. 5d. for income-tax—leaving a balance of £41,264. 2s. 9d. From this amount is deducted £23,693. 13s. 4d. (being for interest on debentures £14,027., and for sinking fund £9,666. 13s. 4d.), leaving a balance of £17,570. 9s. 5d., out of which the Directors have placed £6,015 19s. 5d. to the general reserve fund.

The shareholders have received for the six months ending June 30, 1890, an interim payment amounting to 4s. per share, and the Directors now recommend a dividend of 6s. per share, making 5 per cent., free of income tax, for the year ended December 31, 1890; which, with the appropriation to the general reserve fund of £6,015. 19s. 5d., will absorb the balance standing to the credit of the revenue account.

The repairs on the Bolama-Bissao cable have caused an expenditure of £2,092. 9s. 1d. The work was well and promptly done. In view of future repairs of this character, it has been deemed expedient to join with the affiliated companies in obtaining the services of a maintenance ship, which will be available at all times for similar work. This involves a cost of £2,500 per annum.

The several sections of the Company's system of cables are now in good working order.

The traffic, under the arrangements made with the other companies which form a cable communication around the continent of Africa, continues to give good results to this Company.

The Directors who retire by rotation are Sir Henry C. Mance and John Denison Pender, Esq., who, being eligible, offer themselves for re-election. The auditors, Messrs. Deloitte, Dever, Griffiths, and Co., also offer themselves for re-election.

NEW COMPANIES REGISTERED.

AGENCE DALZIEL (LIMITED).—Registered by Burton and Company, 37, Lincoln's-inn-fields, with a capital of £60,000, in £10 shares. Objects: to acquire, as regards France, its colonies and dependencies, the business heretofore carried on by Dalziel's Cable News Agency (Limited), in accordance with an agreement expressed to be made between Dalziel's Cable News Agency (Limited), of the one part, and the Company of the other part, and to carry on generally the business of a news agency for the receipt and supply of news and information of all kinds; also to carry on the several businesses of news paper proprietors, printers, publishers, stationers, telephone, telegraph, and electric light engineers, &c., &c. The first subscribers are:—D. Dalziel, 222, Strand; H. King, 18A, Exchange-buildings, Liverpool; M. Hallett, Beech, wood, Slough; H. F. Jackson, 31, Harrington-gardens, S.W.; W. L. Whittaker, 65, Warwick-road, W.; R. L. Devonshire, 1, Frederick-place, Old Jewry; W. Smith, 9, Providence-terrace, Earl's Court. There shall be not less than two nor more than seven Directors. The first are the first four subscribers to the Memorandum of Association. Qualification, £10. Remuneration, £500, with an additional 10 per cent. after payment of 10 per cent. dividend. Registered June 19th.

ELECTROLYTIC CAUSTIC SODA AND CHLORINE TRUST (LIMITED).—Registered by Walter Webb and Co., 23, Queen Victoria-street, E.C., with a capital of £10,000, in £10 shares. Object: to carry into effect an agreement expressed to be made between James Charles Richardson of the first part, Trevenen James Holland of the second part, and the Company of the third part, for the acquisition of certain patents relating to improvements in the electrolytic production of caustic soda, caustic potash, and other products from their salts, and for improvements in apparatus to be used for electrolytic purposes, and to develop, improve, and bring into public use the said inventions. There shall not be less than three nor more than seven Directors. The first are G. R. Tyler, C. E. Green, R. C. Baxter, R. Vogan, Colonel T. J. Holland, C.B., and J. C. Richardson. Qualification, £500. Remuneration to be determined in general meeting.

LODDINGTON IRONSTONE COMPANY (LIMITED).—Registered by Jordan and Sons, 120, Chancery-lane, W.C., with a capital of £50,000 in £10 shares. Objects: to acquire iron, coal, or other mines in Great Britain, and to carry on generally the several businesses of coal owners, coal merchants, coke merchants, ironmasters, iron founders, brass founders, wood and metal workers, metallurgists, chemical and mechanical engineers, &c.

JOHN LORD AND SON (LIMITED).—Registered by Pritchard, Englefield, and Co., Painters' Hall, E.C., with a capital of £15,000 in £5 shares. Object: to carry into effect an agreement, made June 12th, between John Lord of the one part, and Henry Wallwork of the other part, for the acquisition now carried on by the said John Lord, at Springfield Wire Mill, Leyland, Lancashire, and to carry on generally the business of a wire manufacturer in all its branches. Registered without Articles of Association.

D. STEUART AND CO. (LIMITED).—Registered in Scotland, with a capital of £100,000 in 10,000 shares of £10 each. Object: to adopt and carry out an agreement, dated 10th inst., between Duncan Steuart and Co. and Mr. Duncan Steuart, the sole partner of that firm, to purchase the property, effects, and business of the firm of Duncan Steuart and Co., as carried on by them at London-road Ironworks, Glasgow, and elsewhere, as engineers; millwrights, boiler-makers, coppersmiths, founders, and general merchants, and to carry on the business of iron and steel manufacturers, and manufacturers of machinery of every description.

CITY NOTES, &c.

ANGLO-PORTUGUESE TELEPHONE COMPANY.—Coupons No. 7 of the First Mortgage and No. 2 of the Second Mortgage Debentures of this Company will be paid, less income-tax, by the Alliance Bank, Bartholomew lane, on and after the 1st prox.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the past week amounted to £5,628.

CITY AND SOUTH LONDON RAILWAY COMPANY.—The traffic receipts of this Company for the past week amounted to £721. The aggregate receipts for the half-year to date are £18,500.

MANITOBA ELECTRIC AND GAS LIGHT COMPANY.—Messrs. Robert A. McLean and Co. will, on and after July 1st next, pay the half year's interest, due on that date, on the Six per Cent. First Mortgage Debentures of this Company.

SOCIETE GENERALE DES TELEPHONES.—The report submitted to the shareholders at the annual general meeting, recently held in Paris, showed a profit for 1890 of 1,012,698fr., out of which it was proposed to pay a dividend of 18fr. per share, to add 33,072fr. to the reserve, and to carry forward 79,625fr. Surprise was expressed by some of the shareholders at the smallness of the dividend, it having been expected that 30fr., or at least 27fr. 50c., per share would have been declared; but the Directors' recommendation was eventually adopted.

TELEPHONE COMPANY OF AUSTRIA.—Coupon No. 13 of the Five per Cent. Debentures of this Company will be paid, less income-tax, by Messrs. Martin and Co., Limited, 68, Lombard-street, E.C., on and after the 1st prox.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The coupons due June 30th on the debentures of the above Company will be paid by Messrs. Barclay and Co., Lombard-street. Coupons must be left three clear days for examination.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—Application has been made to the Stock Exchange Committee to allow 5,324 additional shares of this Company (Nos. 92,048 to 97,371) to be quoted in the Official List. The traffic receipts of this Company for the week ended June 19, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,984.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, June 17.	Price Wednesday, June 24.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending June 24. Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
£1,300,980	Stock	12/0	Anglo-American	46 47	46 47	6 2 4	Jan., Apr., July, Oct.	47 ..	..
£2,849,510	Stock	21/0	Do. Preferred	84 85	84 85	6 15 4	" "	85	84½
£2,849,510	Stock	..	Do. Deferred	11 11½	11 11½	..		..	..
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99 102	99 102	3 18 5	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine	11¾ 12¼	11¾ 12¼	6 2 5	Mar., June, Oct., Dec.	12	11⅞
£69,200	£100	5%	Do. 5 per Cent. Bonds	101 104	101 104	4 16 2	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	104 108	104 108	4 12 7	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	106 108	106 108	6 0 4	April and October ..	106	105½
16,000	10	8/0	Cuba Submarine	10½ 11½	10½ 11½	6 19 2	February and August	11½	10⅝
6,000	10	10%	Do. Preference 10%	16½ 17½	16½ 17½	5 14 3	" "	..	..
12 931	5	3/2½	Direct Spanish (£4 paid)	3¾ 4¼	3¾ 4¼	6 11 9	April and October ..	..	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	10⅜ 10⅝	10⅜ 10⅝	6 11 9	Jan., Apr., July, Oct.	10⅝	10⅞
400,000	10	2/6	Eastern	14½ 14⅝	14⅝ 14¾	4 7 5	" "	14⅝	14⅝
70,000	10	6%	Do. 6 per Cent. Preference	15 15½	15 15½	3 17 5	" "	15½	15½
£1,250,000	Stock	6%	Do. 4 per Cent. Mort. Debenture Stock	106 109	106 109	3 13 5	May and November	107½	105½
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	107 110	4 10 11	February & August	108⅝	..
250,000	10	6/6	Eastern Extension	14¾ 15¼	14¾ 15¼	4 11 10	Jan., Apr., July, Oct.	15¼	14⅞
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock	105 108	105 108	3 14 1	..	..	..
£85,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103 106	103 106	4 14 4	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	103 106	103 106	4 14 4	" "	103½	..
180,227	10	2 6	Globe Telegraph and Trust	9½ 9⅝	9½ 9⅝	5 5 1	Jan., Apr., July, Oct.	9⅝	9½
180,042	10	6%	Do. 6 per Cent. Preference	15 15½	15 15½	3 18 8	" "	15⅞	14⅝
150,000	10	8¾ fr 90	Great Northern	18½ 19	18½ 19	4 9 6	Jan., April, and July	18⅞	..
£ 20,000	100	5%	Do. 5 per Cent. Debentures, 1883	105 108	105 108	4 12 7	March & September	..	..
17,000	25	37/6	Indo-European	39 41	39 41	4 11 6	May and November	..	..
38,348	10	5/0	London Platino-Brazilian	6½ 7⅛	6½ 7⅛	6 0 0	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106 109	106 109	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's	8 8½	8 8½	4 14 1	April and October ..	..	..
3,381	£100 Cert.	6%	Submarine Cables Trust 6%	114 118	113 117	5 2 7	" "	116½	..
15,609	10	4/0	West African Telegraph	8 9	8 9	5 11 1	January and July ..	..	..
£281,400	100	5%	Do. 5 per Cent. Debentures	95 98	95 98	5 2 0	March & September	..	..
30,000	10	2/0	West Coast of America	3½ 4½	3½ 4½	..	January and July ..	..	..
£150,000	100	8%	Do. Debentures 8% 1902	100 105	100 105	7 12 5	June and December	..	—
88,321	10	9d.	West India and Panama	2⅝ 3	2⅝ 3	..	" "	2⅛	2⅛
34,563	10	6/0	Do. 6 per Cent. 1st Preference	10⅝ 11⅛	10⅝ 11	5 9 1	May and November	10⅞	10⅝
4,669	10	34/6	Do. 6 per Cent. 2nd Pref.	9½ 10⅜	9½ 10⅛	5 14 3	" "	..	..
61,683	15	9/0	Western and Brazilian	11¼ 11⅝	11¼ 11⅝	6 7 10	" "	11⅝	11
30,364	7½	1/6	Do. 5 per Cent. Cumulative Preferred	6½ 7	6½ 7	5 7 3	—	6⅝	..
30,264	7½	7/6	Do. 5 per Cent. Deferred	4½ 5	4½ 5	..	..	4⅝	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103 106	103 106	5 13 2	February & August	104	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103 106	103 106	5 13 2	" "	104	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	117 122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bond	100 104	100 104	5 15 5	March & September	..	..
			TELEPHONES.						
224,850	14/0	0/4½	Consolidated Telephone Const. & Maintenance	1⅛ 1⅜	1⅛ 1⅜	..	May and November	..	..
220,000	£1	4·76	Oriental (11s. paid)	½ ⅝	½ ⅝	5 2 11	Yearly	..	..
438,984	5	2/6	National	4⅞ 5	4⅞ 5⅛	5 7 4	June and December	5⅛	4⅞
15,000	10	6/0	Do. 6 per Cent. Cumulative 1st Pref.	12½ 12⅝	12½ 12⅝	4 14 1	" "	..	..
15,000	10	4/9⅜	Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd)	12 12½	12 12½	3 16 10	" "	..	..
350,000	£100	4½%	Do. Debenture Stk. 4½% Prov. Cert. (fully pd)	104 106	104 106	4 4 11	..	105⅜	105
58,000	5	1/0	United River Plate	2½ 3½	2½ 3½	..	January and July ..	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85 95	85 95	5 5 8	..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
1,000	£50	..	City of London Electric Lighting Shares (£25 pd)	33 37	36 37	..	..	..	—
19,900	£5	..	Electricity Supply Co. of Spain	4½ 5	4½ 5	..	..	..	..
5,322	£5	..	House to House Electric	4½ 5½	4½ 5½	..	..	..	..
30,000	£5	..	Liverpool Electric Supply (£3 paid)	2⅛ 2⅜	2⅛ 2⅜	3 13 1	..	..	..
111,000	5	..	London Electric Supply	1⅞ 2⅛	1⅞ 2⅛	..	..	..	..
43,900	10/0	2/0	Metropolitan Electric Supply (fully paid)	8½ 9½	9⅜ 10½	4 7 7	..	10⅛	9⅜
7,730	£5	..	St. James' and Pall Mall	5⅛ 6⅛	—		..	..	..
..	..	7%	Do. 7% Preference	⅜ 1 prem	½ 1	—	..	..	..
42,853	5	..	Westminster Electric Supply (£5 paid)	4¼ 5¼	4¼ 5¼	..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	..	Brush Electrical Engineering	2½ 2⅝	2⅝ 2⅞	..	..	2¼	2⅛
69,996	2	1/1	Do. 6 per Cent. Preference	1⅝ 1⅞	1⅝ 1⅞	6 8 0	June and December	1⅞	1⅝
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	4 5	4 5	7 0 0	January and July ..	..	..
17,130	5	..	Edison and Swan United	.. ..	.. ..	..	—	..	..
45,000	10	6%	Electric Construction	3 4	3½ 4½	..	—	3⅜	..
70,000	2	10/0	Elmore's Patent Copper Depositing	3 3½	3 3½	..	—	3⅛	3⅛
20,000	5	..	Fowler-Waring Cables (£4 paid)	2 3	2 3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	18½ 19½	18½ 19½	5 2 7	February & August	19¼	..
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103 106	103 105	4 5 9	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	7½ 8½	7½ 8½	11 15 3	..	..	..
11,334	£10	5/0	Do. Preference	9½ 9⅝	9½ 9⅝	8 4 1	..	..	..
78,949	5	2/1½	Swan United (£3. 10s. paid)	4½ 5	4½ 5	6 19 10	May and November	4½	..
37,350	12	36/0	Telegraph Construction and Maintenance	46 48	46 48	5 0 0	March and July	46½	46
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	103 106	103 106	4 14 4	January and July ..	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£3 paid)	2⅛ 2⅝	2⅛ 2⅝	..	..	..	..
..	£5	..	Do. Preference (fully paid)	3⅜ 4⅛	3⅜ 4⅛	..	..	..	..
			RAILWAYS.						
50,000	£10	..	City and South London Railway	4 5	4 5	..	..	..	..

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THE ELECTRICIAN:

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NOTES.

At the last meeting of the Physical Society, Prof. Ayrton read a Paper, by Mr. Mather and himself, on the construction of non-inductive resistances. These resistances are much needed for alternate current testing, as, in every method of measuring the power supplied by varying currents, it is assumed that some portion of the circuit is non-inductive. For such purposes a conductor is required, the current taken by which is always proportional to the voltage applied to it, whether the volts be high or low, steady or alternating. The objection to liquid resistances is their want of constancy, and wire resistances, if wound spirally, appear to possess enough self-induction to introduce considerable errors into the measurements. The authors of the Paper have succeeded in constructing resistances whose inductance cannot be measured by the secohmmeter, the most sensitive instrument at their disposal; and they have also pointed out a simple way of making resistance coils suitable for strong currents, in which the self-induction is so diminished that the errors introduced thereby are much smaller than those caused by the use of the best instruments employed in practice.

At the same meeting, Mr. Vernon Boys showed a number of delicate electrometers, which he has recently devised, and in which great sensibility has been obtained by making the various parts as small and light as possible, and by reducing the controlling force to a minimum. Success in this direction is only possible after the elimination of all extraneous disturbing forces. The most ordinary electrometer is in one sense a very delicate instrument, the forces brought into play being much smaller than in a galvanometer of the same style of workmanship. The only limit to its sensibility is imposed by external disturbances, such as those caused by viscosity in the suspending fibre, which make their presence apparent when the controlling force is sufficiently reduced. By using a fine quartz fibre, both as a means of suspension and as a torsional control, much of the uncertainty due to extraneous effects is got rid of, and Mr. Boys has succeeded in making instruments more than a thousand times as sensitive as those of the ordinary type, and without any loss of reliability in use.

The aim of Mr. Boys was not to produce instruments of a commercial type, but to find out how sensitive they could be made. He has succeeded admirably, and the production of an instrument which will measure with certainty a small fraction of a volt when the needle is only charged to the potential of contact of two metals, is a most remarkable achievement. We already possess in the capillary electrometer, an improved form of which we describe in this issue, an exceedingly sensitive instrument. It is, however, useless for the measurement of, say, 100 volts, and cannot be altered so as to be applicable for such purposes. Mr. Boys's instruments, however, appear to be far more hopeful in this respect, although the moving parts are so light that no sort of pointer could be used except the mirror and ray method employed with ordinary reflecting instruments. It should be noticed that Mr. Boys started to compete with the ordinary electrometer under a handicap of 2,000 or 3,000 to 1; that is to say, while it is usual to charge an electrometer needle to some 2,000 volts or more, he has restricted himself to the contact difference of 0·8 volt. His success is to be attributed to no new application of forces, but merely to attention to structural details, among which the use of the quartz fibre plays the most important part. In one of these instruments the fibre is only 1in. long, while the period of swing is 35 seconds, and might be arranged to be one minute.

A new departure is being made in the examinations of the Finsbury Technical College, which institution is nothing if not practical. The new examiners, Prof. S. P. Thompson and Mr. G. Kapp, propose to set no questions requiring mathematical knowledge, beyond that of quadratic equations, and of the simple trigonometrical quantities, sine, cosine, &c., and the ability to plot values in the form of curves. So far, there is nothing very original, but the candidates are strongly recommended to learn the use of the slide rule, and should bring them to the examination. Greater accuracy in working out examples than can be obtained by the use of the slide rule is not required. This, for an engineering examination, is a thoroughly sensible idea, and is one which has already been tried at Hanover-square. In the Honours Grade, the student may, during the examination, use an electrical engineering pocket book, but if he avails himself of this he must state the title of the book on his answer paper, and in his answers give references to the pages of the book he has consulted. This is an excellent move, but there is no reason why it should stop at pocket books. In after life the engineer never dreams of trusting to his memory for figures and formulæ if the job in hand be of any importance; he has quite enough to do in working out the problems and in keeping the practical requirements and precautions in mind. Examinations being, unfortunately,

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jobs of considerable importance to many young men, it seems fitting that they should be arranged, if possible, to resemble the work for which, it is to be presumed, their training has prepared them.

We print in this issue an account of a valuable investigation by Prof. Hertz on the mechanical actions of electrical waves. As with all the previous experimental work of the celebrated scientist, the apparatus employed is of a very simple character, so much so, indeed, that the precision of the results obtained is very remarkable. The research brings out more strongly than ever the great complexity of the actions going on within the dielectric. The phenomena of ordinary alternate currents are at present more than sufficient to tax the powers of electricians, while currents having a frequency as high as ten thousand per second, such as have been used by Tesla and Thomson-Houston in America, give rise to effects which at present defy explanation. The currents accompanying electric oscillations are, however, of much higher frequency, and the phenomena accompanying them are more complex still. The oscillations of electric and magnetic force are closely dependent on one another, like the undulations of potential and current which occur with ordinary alternate currents, and hence the difficulty of separating their effects. Prof. Hertz wished to detect the action of the waves on small isolated bodies, in order to obtain results which could not be explained by any theory of action at a distance. In this effort he was, unfortunately, unsuccessful, owing to the minuteness of the forces called into play. At the same time the phenomena of interference, which his previous work has so conclusively demonstrated, form the most convincing proof of the theory that the forces in the ether are propagated gradually from place to place by the action on each other of contiguous portions of the medium.

In some comments on the electric lighting of Cambridge, in our last issue, we stated erroneously that Prof. Garnett was connected with the Newcastle Electric Lighting Company. We learn from Prof. Garnett that, except that the mains of this Company are connected through a transformer, and, therefore, presumably through the ether, with his lecture table, he has no connection of any kind with this or with any other commercial business. We are very glad to correct this statement, which was founded on a verbal misunderstanding as to some tests which he has been making, and to add that Prof. Garnett has declined to undertake the position of superintending engineer to the Cambridge Town Council. He will confine himself to making certain tests of plant, and acting generally in a consultative capacity.

An official communication was made, some three months ago, by the German Government, through the Foreign Office, requesting that "Mr. Preece, Postmaster-General," Dr. J. Hopkinson, Prof. Ayrton, Prof. S. P. Thompson, Dr. Fleming, and Mr. Kapp, might be appointed to serve as delegates for the British Government at the conferences to be held at the Frankfort Exhibition. This request was duly transmitted by the British Government to these gentlemen, accompanied by the observation that, as there were no funds, the delegates would have to go at their own expense. All these gentlemen, we understand, accepted, and were requested to present themselves last Monday for a week's duty, and, further, attend from August 5th to September 30th. It appears that they are simply wanted as jurymen, and one of them asks pathetically what he has done that he should be condemned to seven weeks hard labour at his own expense.

Royal Institution of Great Britain.—The general monthly meeting of the above will be held on July 6, at 5 p.m.

Institution of Electrical Engineers.—A *conversazione* in connection with the above will be held on Monday next, at the Institute of Painters in Water Colours, Piccadilly, at 9 p.m.

Electric v. Horse Cars.—According to the President of the West End Street Railway Company of Boston, electric traction means to that Company a saving of 21 per cent., the cost per electric car mile being 26 cents, as against 33 cents for horse cars.

Long Telegraph Lines.—India can boast of some lengthy telegraph lines, as will be seen by the following figures relating to the six longest:—Calcutta-Kurrachee 1,727 miles, Calcutta-Bombay 1,343 miles, Calcutta-Madras 1,178 miles, Calcutta-Rangoon 1,003 miles, Bombay-Kurrachee 838 miles, Bombay-Madras 794 miles.

Young v. the American Telephone Company.—Mr. Justice Kekewich, on the application of two of the defendants (the American Telephone Company and Mr. Mason, the president of the Company), stayed all further proceedings in this action, on the ground that they were frivolous and vexatious, and that the matter had been disposed of in two previous actions.

Electric Lighting in Belgium.—The following are the number of lamps connected up to central stations in five of the principal towns in Belgium:—

Town.	Arcs.	Incandescents.
Brussels	544	9,507
Antwerp	240	1,481
Ghent	220	4,931
Liege	384	2,040
Verviers	665	2 423

Output of Copper.—The production of copper in Chili during 1890 amounted to 26,300 tons. For the present year it is expected that, in consequence of the civil war, the output will only reach about 16,000 tons. The diminution in the production during the first three months of this year was not very serious, being only 1,513 tons less than in the corresponding period of 1890.

Obituary.—We regret to announce that on Saturday morning Mr. Mackenzie, the Secretary of the General Electric Power and Traction Company, was drowned in the Thames at Hampton while bathing with Mr. Clarke, who was on a visit to him at that place. Mr. Mackenzie was seized with the cramp soon after plunging into the river from one of the islands, and Mr. Clarke himself was almost drowned in trying to save him. Mr. Mackenzie was unmarried, and only 37 years of age.

Improvements in Fusible Cut-outs.—Mr. A. H. Walton writes to inform us that Messrs. Mavor and Coulson's method of wiring is in a great measure covered by his patent No. 5,233 of 1880. He has forwarded us a copy of the specification, which describes fuse blocks held by springs and provided with brass caps to protect the fuse from abrasion. If Mr. Walton can uphold his patent we think that his first claim is of considerably more importance. It runs as follows:—"In electrical circuits a contact bar for any number of fuses, this contact bar to form a point of distribution."

The Junior Engineering Society.—At the last meeting of this Society, a Paper on "Electrical Storage Batteries" was read by Mr. H. B. Varley, A.I.E.E. The author dealt with the capacity of cells and methods of ascertaining their electrical condition and their grouping; the three chief disorders to which they were subject, viz.: buckling of plates, sulphating, and reverting, were touched upon, their causes and remedies being discussed at length. The weight of batteries, their cost, and

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descriptions of some recent forms of cells, the Electric Construction Co's., Reckenzaun's, Crompton's, Howell's, and Drake and Gorham's, concluded the Paper.

A Substitute for Platinum.—Under the guise of "a method of amalgamating glass with other metals than platinum," a sensationally worded Dalziel telegram attributes to Captain Walter, lecturer at the Military Academy of Vienna, "an invention which has been patented in every country in the world. It will effect a revolution in the manufacture of electric lamps, which will be immensely cheapened by it, as the use of platinum will be entirely discarded." Captain Walter states (according to Dalziel) that his invention will cheapen the manufacture of lamps by 100 per cent., while breakage will not hereafter amount to 5 per cent.

Mediterranean Submarine Cables.—The Italian submarine cable vessel "Città di Milano" has lately laid for the Spanish Government a cable from Almeira to the Spanish African fort of Melilla, not far from the Algerian frontier, the length of which is 76 miles. This cable is now being used. The same vessel is at present engaged in laying a cable in the Straits of Gibraltar, between Ceuta and Tunora, also for the Spanish Government. A connecting line between Tunora and Algeçiras will subsequently be established. A cable will immediately be laid between Tarifa and Tangier, so that Gibraltar will be surrounded by a network of telegraph lines. It is stated that the French Government purpose laying a line at once—a land line between Melilla and Némours, in Algeria—so as to establish direct communication through Spain between France and her African possessions. A grant of 5½ francs for cables between Marseilles and Tunis and Marseilles and Oran was agreed to by the French Chamber on Wednesday last.

Reduced Cable Rates.—The Eastern Telegraph Company notifies that several important reductions of tariff, which were arranged at the International Telegraph Conference of Paris, will come into operation on 1st inst. The rate to Spain will be reduced to 4d. per word, Portugal and Gibraltar to 4½d., Canary Islands to 10d., Malta to 6d., Greece to 7d., Turkey to 6½d., Penang to 5s., Singapore to 5s. 9d., Java to 6s., and Sumatra to 6s. 6d. per word. The rates to South and West Australia, Victoria, Tasmania, and New South Wales were very considerably reduced on May 1st last under a guarantee of the Colonial Governments. As neither Queensland nor New Zealand joined in this guarantee, the rates to those Colonies remain unaltered; but, on the 1st proximo, they will both be reduced by 4d. per word, being the amount of the reduction made in the Indian transit rate at the recent Telegraph Conference. In addition to the above, the Post Office notify the reduction of rates to Austria, Hungary, Italy, and Switzerland to 3d. per word; to Sweden to 4d. per word; to Norway, 3½d.; to Russia, 5½d. The rate to Senegal is also reduced to 1s. 6d., and to Singapore to 5s. 9d.

The Society of Arts.—Mr. Thomas Howard, who died in 1872, bequeathed to the Society of Arts a sum of £500 for the purpose of presenting a prize to the author of a treatise on motive power. The prize having on several occasions been offered without any practical result of value, the Council considered that the most useful way of dealing with it would be to invite some eminent authority on the subject to deliver a course of lectures before the Society on a subject coming within the terms of the trust, on the understanding that the lectures should afterwards be published as a treatise on the subject. The result of this was that Mr. Anderson delivered, in 1884-5, the valuable course of lectures which were afterwards re-published under the title of "The Conversion of Heat into Useful Work." Since that time the interest of the fund has accumulated to a sufficient extent to allow the Council to repeat their action, and they have accordingly invited Prof. Unwin to deliver, during the next Session, a course of lectures on "The Generation of Power at Central Stations, and its Distribution therefrom." These lectures will afterwards be published, to form a treatise on the subject.

Destructive Thunderstorm.—A thunderstorm of unusual severity passed over a large portion of England and Wales on Wednesday and Thursday. The spire of St. Saviour's Schools, Liverpool, was struck and considerably damaged. Mr. Alfred Bowen, the head master, says that he observed what appeared to be a great ball of fire descend from the clouds on to the school tower; the whole building was shaken. A mansion near Abergavenny was struck, and the lightning, after breaking the roof, caused serious havoc in the drawing room, where a marble mantelpiece was torn from its place, and part of the furniture destroyed. At Crewe the chimney of a cottage was struck. The lightning entered the house, displacing the fire grate, mantelpiece, and windows, and hurling them together into one mass of *débris*. The yard wall was knocked down and large fissures also appeared in the walls of the house. At Church Coppenhall, near Crewe, a flash of lightning struck the high road near the Church House farm and bored two large holes in the hard macadam, eight feet apart and several feet deep. At Bristol and Clifton two houses were found to be on fire through the bursting or melting of gas pipes and the gas igniting. In each case, however, the fire was extinguished before very serious damage was done.

Telephones and Tramways.—Writing to the *Birmingham Daily Post*, Mr. Frederick Brown says that he has returned from a special visit to America, made for the purpose of inspecting the electric tram systems there, and thinks that the effect of the heavy current on the telephones is over-estimated. In one city, where there had been an attempt on the part of the Telephone Company to stop the introduction of the "electric road," as the Americans term it—and which attempt, by the way, had failed—special means were taken by the Tram Company to notice the effect of the heavy current on the telephone lines. This was done by setting various people to speak to the Telephone Exchange, and then to each other, at the time that the different cars commenced running; and the effect was so little that the telephone *employés* were not aware that the cars were running until their attention was called to the fact, and six cars were out on the streets. The case has been tried in many of the States in the Union, and has, when carried to the higher courts, if not earlier, always gone in favour of the Tramway Company, on the ground that the streets were intended for traffic; and if this can be facilitated by the use of electricity, a small minority of users, like the telephone subscribers are in comparison to the travelling public, must do the best they can for themselves, either by submitting to the slight inconvenience or by running metallic circuits.

A Thermo-Electric Measurement of Steam Condensation.—A new method of studying condensation in steam-engine cylinders has been tried by Prof. E. H. Hall, of Harvard. The object of the investigation was to trace the changes in temperature, and therefore the passage of heat through the sides of the cylinder, by finding the temperature at a particular depth in the iron at a certain instant corresponding with a particular position of the piston. A series of plugs were constructed, each having a hole drilled through it axially, and being provided with a disc of iron at the end. To the centre of the disc a rod of nickel was carefully soldered, making a good joint less than a thousandth of an inch thick. This joint acted as a thermo-electric couple, and a pair of wires of iron and nickel were led to and joined in a pot of melted paraffin. The temperature of the paraffin could be easily regulated and determined, and made to balance the temperature of the junction in the plug. A galvanometer and contact maker were placed in the thermo-electric circuit, and contact was made at a definite point in the stroke, the contact lasting for about one-sixtieth part of a revolution. By using plugs with discs of different thicknesses from half a millimetre to two millimetres, the changes of temperature could be determined, and by plotting curves corresponding to the slope of temperature at opposite points in the stroke, the area between them representing the amount of heat given up to the metal of the cylinder wall could be determined. No great accuracy was arrived at, but the idea is promising.

Gas in Manchester.—At the monthly meeting of the Manchester City Council, on Wednesday next, the Gas Committee will present to the Council their report for the year ending March 31st last. The Committee state that there are 12,076 public lamps in the city, of which 1,420 are of the improved pattern, and 120 lamps are now fixed in dark courts and pas-

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sages. The total value of the gas consumed in public lighting was £22,386. Notwithstanding the increased cost of labour and materials, and the reduction in the price of gas in the recently incorporated townships, the financial results of the year's working have been satisfactory, and the profits realised have considerably exceeded anticipation. The total revenue of the gas department from all sources was £488,425, being £54,073 more than last year. The gross profit for the year was £97,276, and, after paying the usual fixed charges for interest, sinking fund, and providing for street lighting, the net profit amounts to £47,545, out of which there has been paid to the city fund £10,000, the adverse balance of £26,277 has been cleared off, and the sum of £11,268 carried forward to renewals account. The Provisional Order for the supply of electricity within a certain prescribed area of the city has been obtained. The Committee have visited a number of important electric installations in London and elsewhere, and have been in communication with several eminent electric engineers for advice and suggestive reports. When these reports are to hand, and have been examined and decided upon, the recommendations of the Committee will be submitted to the Council. The Committee assure the Council that there will be no avoidable delay in making this illuminant available to the public.

University College Engineering Society.—At a *conversazione* held in University College, London, on Tuesday, June 30th, the above Society gave an exhibition of machinery, instruments, models and drawings, in the Engineering Laboratory. The temporary electric lighting was undertaken by the Keys' Electric Company, of London. The light was given by four arc lamps, and an electrolier with six incandescent lamps; the necessary current being supplied by one of the firm's 10-H.P. dynamos working at 110 volts, and running from a Crossley gas engine, indicating 8·H.P., at 1,250 revolutions. The firm also lent a very complete exhibition of electrical appliances. Messrs. Siemens Bros. and Co., and Messrs. Ferranti also gave a very interesting display of electrical instruments, as well as their electric cables. There were several steam engines, a Worthington pump, a small alternate current dynamo, and a model of Brotherhood's three-cylinder engine and pump in motion; whilst numerous models and photographs of Joy's valve gear, Giffard's injectors, Kennedy's water-meter, brick-making machine, torpedo, Holden's liquid fuel injector, Donkin's sprung piston rods, gas exhauster, and four-way valve, Sulzer's valve gear, Hero, Savory, and Newcommen engines, a cylinder of Robey engine with automatic valve gear, represented various branches of mechanical engineering. The laboratory testing machine, capable of exerting a pull of 100,000lbs., was shown, and the method of testing demonstrated, numerous tests in tension, compression, shear, and bending being displayed. The method of testing cement was fully illustrated. The engineering laboratory formed a centre of attraction throughout the evening.

Edison as a Witness.—The free-and-easy style of taking evidence under commission in the United States gives a witness a fair chance of doing himself justice. We never know how to take Mr. Edison, and leave our readers to judge what he really meant by the following answers:—

Q. You recognise the fact, do you not, that in this art of incandescent lighting there is a certain practical relation existing between the size and proportions of the incandescent burner and the character of the conductors employed to carry the current to the lamp?—A. That depends upon what system you use.

Q. I assume, and ought to have said in my question, that the lamps are to be arranged in multiple arc?—A. There is no such relation.

Q. Do you consider yourself the discoverer of that relation?—A. I do not consider myself the discoverer of Ohm's law, and Ohm's law will explain all things that have been done, and it will probably explain everything that will be done in the next thousand years, in electricity.

Q. Is that the best answer that you can make to the question?—A. I don't like to be drawn in as an expert; I am not an expert on the question of words. I will answer questions of facts, but I do not like to expert.

Q. It does not occur to me that I am examining you as an expert on this matter; I simply ask you whether you consider that you are the person who discovered the relation that exists between the size and proportions of the burner of an incandescent lamp and the character of the conductors employed to convey the current to such lamp when the lamp is being used in multiple arc?—A. I do not know whether I am or not in relation to an incandescent lamp. Ohm's law did not mention incandescent lamps. It is a broad general law. I think I have already stated a sufficient answer.

Q. I will put this question, then: Did not you know, as a matter of inference from Ohm's law, at the time when you began your experimentation with incandescent lamps, that with a given size of conductor it would be necessary to give the individual lamps a higher resistance if they were to be used in multiple arc than would be necessary if they were to be used in series?—A. It is not necessary in applying Ohm's law at all, but when you bring in the commercial element in connection with that law, then it is; the fact of the matter is that at the time I experimented on the incandescent lamp I did not understand Ohm's law.

Q. Do you mean that you did not know the formula of Ohm's law at that time?—A. No, sir; I did not know it.

Q. When did you first get knowledge of Ohm's law?—A. It may seem strange for me to state that I do not really understand Ohm's law to-day.

Q. I do not ask you whether you understand Ohm's law, but when did you first know of this law?—A. I have heard of Ohm's law for the last 20 years.

Q. What do you mean by saying that you did not know Ohm's law at the time you began experimenting with incandescent lamps?—A. I mean to say that I did not understand Ohm's law. I do not understand Ohm's law now, and, moreover, I do not want to understand Ohm's law. It would prevent me from experimenting.

The Jamaica Exhibition.—News received from Jamaica, says a Dalziel telegram to the *Times*, under date June 15, indicates a feeling of dissatisfaction among the people, largely arising from the financial failure of the recent exhibition, and partly from other causes that have combined to make that failure more conspicuous. That the latest statement made public by the general manager of the affair shows a cash loss of considerably over $100,000 is certainly bad enough, but as that falls only upon a few wealthy men, who guaranteed any deficiency before the project was fully launched, it does not seriously interest the people generally. The cause of the popular resentful feeling is the fact that, while Jamaica imported a manager from England and placed the matters connected with the exhibition unreservedly in his hands, England took no interest in the event, and made no efforts to aid its success. The absence, also, of any personal marks of distinction from the Home Government for the promotion is severely commented upon. In reply to this, Sir Henry Blake strongly protested in the *Times* of Monday. He apparently admits the cash loss of £20,000, but, quoting the statement that it falls only upon a few wealthy men, he asks, "where, then, is there room for the alleged feeling of dissatisfaction?" He goes on to say that not alone did the Imperial Parliament vote £1,000 towards the expenses of the exhibition, but the Queen lent to the Commissioners portraits of Her Majesty and of the Prince Consort. English manufactures were well represented in the English court, and secured several diplomas of honour and gold medals, and two C.M.G.'s were conferred. He adds that the exhibition has increased the revenue of Jamaica last year by over £60,000; extended trade relations; improved local business; stimulated production; cemented all classes by bringing them together to work for a common object; taught self-reliance; advertised the West Indies, and shown to hundreds of foreign visitors that they could live in Jamaica for months without even hearing the name of yellow fever; while the fact that out of the 304,000 people who, during the three months of its duration, visited the exhibition, there was not a single arrest for drunkenness or disorderly conduct spoke conclusively for the general respectability of the population. To call an exhibition giving such results a financial failure, says Sir Henry Blake, is simply an abuse of language. Lord Newport confirms Sir Henry Blake's letter, and adds that he believes that the exhibition was never expected to be a financial success, which he thinks makes all the more creditable the untiring energy and exertions of Sir Henry and Lady Blake, to whom in a great measure were undoubtedly due the pleasure and benefit derived by the thousands of natives. The *Electrical Engineer* of New York, describing the Thomson-Houston plant of the Jamaica Electric Light Company, says it deserves mention that the Company was able to render valuable service in assisting to light up the recent Exhibition. An English concern that had contracted for lighting the Exhibition was unable to live up to its contract, whereupon the local company was asked for help, and was able to afford it in a very substantial manner. In every particular the plant is American, a fact that does not lose in significance because Jamaica is a British colony. Whatever may be the political ties of the island, there can be no question that her commercial relations with America become more and more friendly.

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ELECTROMAGNETIC THEORY.—XI.

BY OLIVER HEAVISIDE.

(Continued from page 96.)

§ 66. One of these extensions refers to the meaning to be attached to the term current, electric or magnetic respectively. As we have seen, electric current, which was originally conduction current only, had a second part, the displacement current, added to it by Maxwell, to produce a circuital flux; and further, when there is electrification in motion, we must, working to the same end, add a third term, the convection current, to preserve circuitality.

A fourth term may now be added to make up the "true" current, when the medium supporting the fluxes is in motion. Thus, let us separate the motional electric and magnetic forces from all other intrinsic forces that go with them in the two circuital laws (voltaic, thermo-electric, &c., § 39); denoting the former by $\mathbf{e}$ and $\mathbf{h}$, and the latter by $\mathbf{e}_0$ and $\mathbf{h}_0$. The two equations of circuitation [(12), (13) § 38, and (6), (7) § 52)] now read

$$\text{curl}\,(\mathbf{H}-\mathbf{h}_0-\mathbf{h})=\mathbf{J}=\mathbf{C}+\dot{\mathbf{D}}+\mathbf{u}\rho, \quad . \quad . \quad . \quad (1)$$

$$-\text{curl}\,(\mathbf{E}-\mathbf{e}_0-\mathbf{e})=\mathbf{G}=\mathbf{K}+\dot{\mathbf{B}}+\mathbf{w}\sigma. \quad . \quad . \quad (2)$$

Now transfer the $\mathbf{e}$ and $\mathbf{h}$ terms to the right side, producing

$$\text{curl}\,(\mathbf{H}-\mathbf{h}_0)=\mathbf{J}_0=\mathbf{C}+\dot{\mathbf{D}}+\mathbf{u}\rho+\mathbf{j}, \quad . \quad . \quad (3)$$

$$-\text{curl}\,(\mathbf{E}-\mathbf{e}_0)=\mathbf{G}_0=\mathbf{K}+\dot{\mathbf{B}}+\mathbf{w}\sigma+\mathbf{g}, \quad . \quad . \quad (4)$$

where $\mathbf{j}$ and $\mathbf{g}$ are the auxiliaries before used, given by

$$\mathbf{j}=\text{curl}\,\mathbf{h}, \qquad \mathbf{g}=-\text{curl}\,\mathbf{e},$$

It is the new vectors $\mathbf{J}_0$ and $\mathbf{G}_0$ which should be regarded as the true currents when the medium moves.

As the auxiliaries $\mathbf{j}$ and $\mathbf{g}$ are themselves circuital vectors, there may not at first sight appear to be any reason for further complicating the meaning of true current when separated into component parts, for the current $\mathbf{J}$ is circuital, and so is $\mathbf{J}_0$, which is of course the same as $\mathbf{J}$ when the medium is stationary. The extension would appear to be an unnecessary one, of a merely formal character.

On the other hand, it is to be observed that from the Maxwellian method of regarding the current as a function of the magnetic force, the extended meaning of true current is not a further complication, but is a simplification. For whereas in the equation (1) we deduct from the force $\mathbf{E}$ of the flux not only the intrinsic force $\mathbf{e}_0$ but also the motional force $\mathbf{e}$ to obtain the effective force whose curl measures the current; on the other hand, in (3) we deduct only the intrinsic force. Away, therefore, from the sources of energy which are independent of the motion of the medium, the force whose curl is taken in (3) is the force of the flux, which specifies the electric state of the medium, whether it be stationary or moving.

To show the effect of the change, consider the example of § 56, in which the medium moves past the charge, and there is continuously changing displacement outside a certain sphere. If we consider $\mathbf{J}$ the true current, we should say there is electric current, although there is no magnetic force. But according to the other way there is no true current, and the absence of magnetic force implies the absence of true electric current.

But still this question remains, so far, somewhat of a conventional one. Is there any test to be applied which shall effectually discriminate between $\mathbf{J}$ and $\mathbf{J}_0$ as the true current? There would appear to be one and only one; viz., that $\mathbf{e}_0$ being an intrinsic force, its activity, whatever it be, say $\mathbf{e}_0\mathbf{x}$, expresses the rate of communication of energy to the electromagnetic system from a source not included therein, and not connected with the motional force $\mathbf{e}$. When the medium is stationary $\mathbf{x}$ is $\mathbf{J}$, and the question is, is $\mathbf{x}$ to be $\mathbf{J}$ or $\mathbf{J}_0$ (or anything else) when the medium moves?

Now this question can only be answered by making it a part of a much larger and more important one; that is to say by a comprehensive examination of all the fluxes of energy concerned in the equations (1), (2), or (3), (4), and their mutual harmonisation. This being done, the result is that $\mathbf{e}_0\mathbf{J}_0$ is the activity of $\mathbf{e}_0$, so that it is $\mathbf{J}_0$ that is the measure of the true current, with the simpler relation to the force of the flux; and it is naturally suggested that in case of further possible extensions, we should follow in the same track, and consider the true current to be always the curl of $(\mathbf{H}-\mathbf{h}_0)$, independently of the make up of its component parts.

This is not the place for a full investigation of this complex question, but the main steps can be given; not for the exhibition of the mathematical working, which may either be taken for granted, or filled in by those who can do it, but especially with a view to the understanding in a broad manner of the course of the argument. Up to the present I have used the notation of vectors for the concise and plain presentation of principles and results, but not for working purposes. This course will be continued now. How to work vectors may form the subject of a future chapter. It is not so hard when you know how to do it.

§ 67. The principle of the conservation or persistence of energy is certainly as old as Newton, when viewed from the standpoint of theoretical dynamics. But only (roughly speaking) about the middle of the present century did it become recognised by scientific men as a universal truth, extending to all the phenomena of Nature. This arose from the experimental demonstrations given (principally those of Joule), that in various cases in which energy disappeared from one form, it was not lost, but made its appearance in other forms, and to the same amount.

The principle is now-a-days a sure article of scientific faith. Its ultimate basis is probably the conviction (a thoroughly reasonable one) that the laws of motion hold good in the invisible world as well as in the visible, confirmed by the repeated experimental verification. But the principle is now believed in quite generally by the ordinary unscientific man, for example, who could not tell you correctly what the principle meant, or energy either, to save his life, although he might tell you that he could not conceive the possibility of energy being destroyed. He goes by faith, having taken it in when young.

So it will be with the modern view of the ether as the medium through which energy is being sent when a wire supports a current. Only train up the young to believe this, and they will afterwards look upon the notion of its going through the conductor as perfectly absurd, and will wonder how anyone ever could have believed it. But before this inevitable state of things comes to pass, an intermediate period must be passed through, in which scientific men themselves are learning to believe the modern view thoroughly from the evidence of ts truth, and to teach it to others. This period is certainly not yet come to its end; for almost weekly we may read about "the velocity of electricity in wires," such language emanating from scientific men who are engaged in repeating and extending Hertz's experiments.

The principle of the continuity of energy is a special form of that of its conservation. In the ordinary understanding of the conservation principle it is the integral amount of energy that is conserved, and nothing is said about its distribution or its motion. This involves continuity of existence in time, but not necessarily in space also.

But if we can localise energy definitely in space, then we are bound to ask how energy gets from place to place. If it possessed continuity in time only, it might go out of existence at one place and come into existence simultaneously at another. This is sufficient for its conservation. This view, however, does not recommend itself. The alternative is to assert continuity of existence in space also, and to enunciate the principle thus:—

When energy goes from place to place, it traverses the intermediate space.

This is so intelligible and practical a form of the principle, that we should do our utmost to carry it out.

The idea that energy has position, therefore, naturally involves the idea of a flux of energy. Let $\mathbf{A}$ be the vector flux of energy, or the amount transferred per unit of time per unit of area normal to the direction of its transfer; and let $\mathbf{T}$ be the density of the energy. We may then write

$$\text{conv}\,\mathbf{A}=\dot{\mathbf{T}}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

or

$$\text{div}\,\mathbf{A}=-\dot{\mathbf{T}}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

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That is, the convergence of the flux of energy is accounted for by increased energy in the unit volume where it converges; or, the divergence of the flux of energy, or the rate at which it leaves the unit volume, is accompanied by simultaneous and corresponding decrease in the density of the energy.

§ 68. Now, there are numerous cases in which the flux of energy is perfectly plain, and only needs to be pointed out to be recognised. The simplest of all is the mere convection of energy by motion of the matter with which it is associated. A body in translational motion, for instance, carries its energy with it; not merely the kinetic energy of its translational motion, but also its rotational energy if it rotates, and likewise the energy of any internal vibratory or rotatory motions it may possess, and other energy not known to be kinetic, and therefore included under "potential energy," which we may have good reason to localise in the body. Even if part of the energy be outside the body, yet, if it be associated with the body, it will travel with it, on the whole, and so (at least sometimes) may be considered to be rigidly attached to it. This case may be regarded as the convection of energy, if we do not go too closely into detail.

When energy is thus conveyed, the energy flux is $\mathbf{q}T$, where $\mathbf{q}$ is the velocity and T the density of the energy conveyed (of any kind). If, then, *all* energy were conveyed, equation (5) would become

$$\text{conv}\, \mathbf{q}T = \dot{T}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

Now this equation, if we regard T as the density of matter, is the well known equation of continuity of matter used in hydrodynamics and elsewhere.

This brings us to Prof. Lodge's theory of the identity of energy. (*Phil. Mag.*, 1885.) Has energy personal identity, like matter? I cannot see it, for one; and think it is pushing the principle of continuity of energy, which Prof. Lodge was writing about, too far. It is difficult to endow energy with objectivity, or thinginess, or personal identity, like matter. The relativity of motion seems to be entirely against the idea. Nor are we able to write the equation (7) in all cases. Energy may be transferred in other ways than by convection of associated matter. If we atomise the energy we can then imagine the $\mathbf{q}$ above to be the velocity of the energy, not of the matter. But as the science of dynamics is at present understood, we cannot make use of this idea profitably, I think.

The chief reason why the founders of the modern science of energy did not explicitly make use of the idea of the continuity of energy was probably the very obscure nature of gravitational energy. Where was it before it became localised as the kinetic energy of a mass? It is of no use to call it potential energy if that is to explain anything, which it does not. It would seem that the energy must have been in the ether, somewhere, and was transferred into the body, somehow. This makes the ether the great store-house of all gravitational energy. But we are entirely ignorant of its distribution in the ether, and of its mode of transference.

Observe here that ether must be regarded as a form of matter, because it is the recipient of energy, and that is the characteristic of ordinary matter. There is an unceasing enormous flux of energy through the ether from the Sun, for instance, and we know that it takes several minutes to come; it comes through the ether, without bringing the ether with it; it is not a convection of energy, therefore. Of course, to avoid confusion, it is well to distinguish ether from ordinary matter by its separate name; but it is important to note that it *has* some of the characteristics of ordinary matter. It need not be gravitating matter; it is, perhaps, more likely to be the medium of gravitational action than to gravitate itself.

In default of ability to represent the flux of gravitational energy its entry into a body must be otherwise represented than by the convergence of a flux. Turn (7) into

$$\mathbf{f}\mathbf{q} + \text{conv}\, \mathbf{A} = \dot{T}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

Here $\mathbf{f}\mathbf{q}$ is the activity of the force $\mathbf{f}$, and indicates energy communicated to the unit volume in an unstated manner, generated within the unit volume, so to speak. The force $\mathbf{f}$ is thus an impressed force. By this device we can allow for unknown fluxes of energy. We should also explicitly represent the convective flux. Thus,

$$\mathbf{f}\mathbf{q} + \text{conv}\,(\mathbf{q}T + \mathbf{A}) = \dot{T}, \quad . \quad . \quad . \quad . \quad . \quad (9)$$

where $\mathbf{A}$ is the flux of energy other than convective, not associated with $\mathbf{f}$.

When a stress works, for example, we shall have a flux of energy, $\mathbf{A}$, which can hardly be considered to be convective, in the sense explained, a flux of energy through matter or ether, as in wave propagation through an elastic solid, or radiation through the ether. We can, however, sometimes reduce it to the form $\mathbf{q}T_1$, and then it would *appear* to be convection of energy.

This occurs in a moving frictionless fluid, for example, when the stress is an isotropic pressure p. The flux of energy other than convective is $p\mathbf{q}$. But when we pass to a less ideal case, as an elastic solid, in which the stress is of a more general character, the energy flux expressive of the activity of the stress takes the form

$$\mathbf{A} = -\mathbf{P}_q q, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

where $\mathbf{P}_q$ is the vector expressing the pull per unit area on the plane perpendicular to the velocity $\mathbf{q}$. In this equation q is the tensor of $\mathbf{q}$.

(To be continued.)

NOTES ON PERMANENT MAGNETS.

BY SILVANUS P. THOMPSON, F.R.S.

§ 1. **Laminated Magnets.**—Knight appears to have been the first to employ compound magnets made of bundles of steel plates separately magnetised. Since then many other experimenters have adopted this construction, notably, Geuns, Coulomb, and Scoresby. The advantage of this construction is that, in the methods adopted for hardening steel by sudden quenching, the hardening does not really penetrate far below the surface, and, consequently, the interior softer part of the bar adds nothing to the permanent magnetism, and may even weaken it so far as its external manifestation is concerned. Coulomb employed magnets made up of three laminæ, the central one projecting a little beyond the others, their ends being embedded in a soft-iron pole-piece. Scoresby,* who made many researches on compound magnets, showed that it was advantageous to separate the laminæ to a short distance apart. Some of his magnets, prepared from busk steel, are preserved in the Museum at Whitby. He showed that such compound magnets may be made much more powerful than any single bar, of weight equal to the combination, can be made; but that the absolute gain of power in the combined mass, due to each additional lamina, diminishes progressively. For example, in a set of 30 plates the last 26 did not add to the first four more magnetic power than the first six had possessed alone. This is due to the tendency to mutual demagnetisation; for in a powerful set the weaker plates not only add nothing but have their polarity actually reversed by the more powerful ones. This state of things is partially remedied by preventing the actual contact of the plates, by interposing sheets of paper or brass. Scoresby found that for compound horse-shoe magnets the best temper was not glass-hard. He found it better to temper the hard steel plates by boiling them in linseed oil at 505°F (=263°C). In this way he raised the lifting power of a 5-plate Stubbs' steel horse-shoe weighing 2·91lb. from 13-14lb. to 25-26lb. And another 15-plate magnet weighing 8lb., which when glass-hard would only carry 26lb., when thus tempered carried 45-50lb. Jamin,† who has gone over the same ground, has added little to the very complete investigations of Scoresby. Some makers of compound magnets arrange the tiers of plates in the form of steps at the extremities, the central plates being made longer than those on either side. There is no great gain in this arrangement, which is supposed to prevent the central plates from being reversed in

* Scoresby's "Magnetical Investigations," Vol. I., pp. 98—329.

† *Comptes Rendus*, LXXVI., 1873, and in innumerable Papers in the same journal since.

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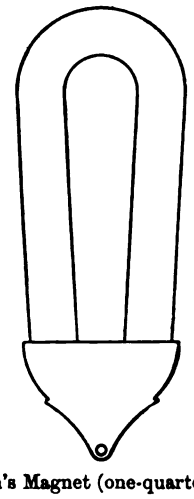
polarity by those outside. It probably has the advantage of concentrating the magnetic lines, and so adding to the lifting power. Van der Willigen considered one millimetre a sufficient amount of projection for the central plate.

§ 2. **Traction or Lifting Power of Magnets.**—Bernoulli's law that the tractive power of similar magnets was in proportion to the $1\frac{2}{3}$th root of their weight, or, in other words, to the square of the cube root of their weight, was explained in my Cantor Lectures on the Electro-magnet, and shown to mean merely that for equal magnetic saturation the tractive power was simply proportional to the polar area. If P stands for the greatest load which the magnet will carry, and W for its own weight, then Bernoulli's rule is

$$P = a \sqrt[3]{W};$$

where a is a constant depending on the units chosen, on the quality of steel, and on its degree of magnetisation. If P and W are expressed in kilogrammes, then, according to the data of the best makers, a for horse-shoe magnets will be between 18 and 24, or, say, on the average, 20. This means that if we consider a magnet weighing 1 kilogramme, it will carry a load of 20 kilogrammes, or 20 times its own weight. On this reckoning a magnet weighing 10 kilogrammes should carry 92·8 kilogrammes, or $9\frac{1}{4}$ times its own weight; whilst a magnet weighing 0·1 kilogramme should carry 4·31 kilogrammes, or 43 times its own weight. If P and W are given in British pounds the value of the coefficient for the best sort of horse-shoe magnets (corresponding with $a = 20$ for kilogramme units), will be 25·1, or, approximately, 25. That is to say, a really good steel horse-shoe magnet, weighing 1lb., should carry a load of 25lb. For example, one of Van Wetteren's magnets examined by Van der Willigen (magnet "B") weighed 1·074lb., and carried, as the mean of seven observations, a load of 26·004lb.

§ 3. **The Haarlem Magnets.**—The Haarlem magnets have been so justly celebrated for their admirable qualities



Van Wetteren's Magnet (one-quarter actual size).

that some notice of them seems to be called for. Logeman, who was continually advised by M. Elias, was the first to establish a name for the magnets made in Haarlem. By him, Van Wetteren, a most accomplished master smith, had been employed. Later, when Funckler succeeded to Logeman's business, both Van Wetteren and Funckler continued to produce magnets on Elias' plan, until, in 1874, M. Van der Willigen superseded that method of magnetisation by a special method of magnetising upon the poles of a Ruhmkorff's electro-magnet, and applied it to the magnets forged by Van Wetteren. Of the special kind of steel employed, and of the mode of hardening and tempering adopted, nothing precise is stated in the otherwise valuable memoir of Van der Willigen* on the subject. In this memoir a detailed account is given of about 50 magnets and of the loads which they carried after being magnetised in various ways and at various times. Most of these magnets were of the form shown in the figure. The contact surface of the keeper is slightly rounded. The Figure is exactly one-quarter the natural size of the magnet "A" in the following list:—

Mark on magnet.	Weight of magnet, in kilos.	Average load carried, in kilos.	Value of coefficient a.
A	0·495	13·30	21·25
B	0·487	11·78	19·03
E	0·889	19·02	20·57
3057	1·013	21·71	21·52
3053	1·521	27·90	21·17
3054	1·918	32·53	21·07
C	2·169	35·47	21·10

The magnet "A" was 0·66 centims. thick, its keeper 0·3 centims. thick, the polar ends were 2·57 centims. apart, and each of them was 2·68 centims. wide. The extreme height from the outer side of the bend to the middle point between the poles was 17 centims. The area of the polar face was 1·769 sq. centims. The greatest width between the limbs below the bend was 3·65 centims. The magnets "A," "B," "E," and "C" were from one bar of steel. The magnet "3,053" was one shown in the Exhibition of Scientific Apparatus at South Kensington, in 1876, whilst "3,054" was sent to the Centennial Exhibition, at Philadelphia, in the same year. When returned from the States in May, 1877, it was re-magnetised, and carried 31·44 kilogrammes.

So far as the author is aware, no British manufacturers have equalled the Haarlem makers; certainly none has surpassed them.

Scoresby* mentions a nine-plate compound horse-shoe in his possession, weighing 22lb., which would carry from 66 to 88lb. By Bernoulli's formula, a 1lb. magnet, proportionately magnetised, would carry from 8·4 to 11·3lb.—less than half the load which a 1lb. Haarlem magnet will carry. Scoresby also mentions a seven-plate steel horse-shoe made by Dr. Schmidt, the property of the Royal Institution, which, though weighing 16lb., would only carry 28lb. Had this been a Haarlem magnet it would have carried at least 150lb.

Van der Willigen gave another formula for the tractive force of the Haarlem magnets, namely:—

$$P = B \cdot K \sqrt{S} \sqrt[4]{\frac{L}{S}} \frac{L}{l};$$

where P is the tractive force in kilogrammes, S the area of one polar surface (in sq. centims.), K the perimeter of one polar extremity, l the actual mean length of the horse-shoe, L the "reduced" length (*i.e.*, the length between the points of maximum free magnetism observed on the flanks of the magnet, when keeper is in place), all the last being given in centimetres. B is a coefficient which varies between 0·7 and 1·2, and has a mean value of 0·891.

The tractive power of bar magnets is, of course, much less than that of horse-shoes of equal weight, since the keeper is never so highly magnetised when applied to one pole. Van der Willigen states that for Van Wetteren's bar magnets the load carried by one pole is just a quarter of the load which a horse-shoe (of weight equal to that of the bar) would carry. This means that Bernoulli's coefficient a (for kilogramme units) must be taken at about 5 for Haarlem bar magnets. The corresponding number for pound units will be $6\frac{1}{4}$. Has any British maker yet produced a steel bar magnet weighing 1lb. which will carry $6\frac{1}{4}$lb. on one pole?

ELECTRIC LIGHTING IN THE CITY.

The 26 arc lamps which have been erected in Queen Victoria-street, and which constitute as yet the only visible result of the work which is being carried out in the City, were run on Thursday last, for public demonstration, and for the purpose of affording the Commissioners of Sewers an opportunity of inspecting them, the gas lamps being extinguished.

The opinion of the daily Press, which is perhaps a thoroughly representative one, was very favourable. The light is described

* Sur le Magnétisme des Aimants Artificiels. "Arch. du Musée Teyler" (Haarlem), Vol. IV., 1878.

* *Op. cit.*, p. 244.

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as "brilliant, yet soft." "The old objection with regard to the depth of shadows thrown by the lights has been largely modified. The lights also burned quite steadily, with hardly an exception, and there was little or no variation in their intensity." One paper compares the effect to moonlight, and says that, "although every object was plainly visible, there was perfect rest for the eyes." All are agreed that this first instalment is a success, and that the gas lights in the neighbouring streets were mere sparks of dim red fire. After all, it is the opinion of the general public that is to be consulted, since theirs are the requirements to be satisfied. The value of the lighting cannot be properly estimated until the winter, when the streets are crowded after dark; and before the long evenings set in many more streets will probably be lighted. On entering the top of Queen Victoria-street, after walking along Cheapside, where clusters of four gas-burners are provided in each lamp, the general effect was very good, but not particularly remarkable. Having walked the length of the street, and glancing up New Bridge-street, which is lighted simply by gas, the contrast seemed very much more marked than on entering the well illuminated thoroughfare from Cheapside. It is this contrast, rather than the usefulness of the increased illumination, which will cause arc lighting to spread in our streets. The public are fairly satisfied with good gas lighting, but they will complain about it as soon as they leave a district lighted by arcs.

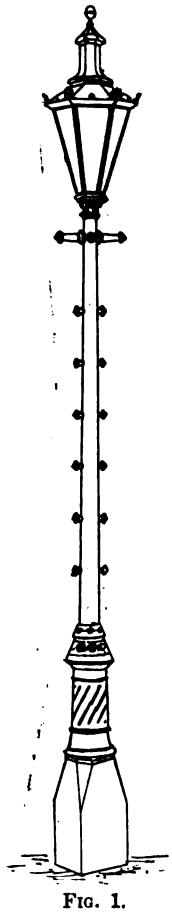

Fig. 1.

The arc lamps are placed on columns 19ft. high (Fig. 1), and are enclosed in lanterns of agreeable proportions. The columns are about 120ft. apart, and are placed alternately on either side of the street. The lanterns are octagonal, and are provided with panes of glass, of which three kinds are being tried. Between the Mansion House and Cannon-street a pane moulded with a small obtuse pyramid is used. The angle of the prisms thus formed is sufficient to deflect the light some 8 or 10 degrees, giving a dispersion of 18 or 20 degrees. But on the occasion of our visits the arcs have been so low in the lanterns, and therefore so near the glass, that the part of the pane subtending this angle with the arc was scarcely as large as the palm of one's hand. If the arc had been twice as far from the glass the patch of bright light would have been twice as wide, and its area, and, therefore, the brilliancy or dazzling, would have been reduced to one-fourth. From Cannon-street to Lambeth-hill a figured pane, with a fancy pattern moulded on it, is used. This disperses the light considerably more than the pyramid, the dazzling is less, and the shadows are softened. The rest of the lanterns, as far as St. Paul's station, have opal glass of a thickness sufficient to prevent the position of the arc being seen. The shadows are, of course, soft, and there is a minimum of dazzling at the expense of a considerable absorption, which is impossible to estimate by the eye, but which is probably over 40 per cent. The theoretical limit of diffusion with moulded panes of clear glass is internal reflection; but a dispersion of 40 or 50 degrees can be given. The best way to select a pattern is, no doubt, to try it on a few lamps, as is being done in Queen Victoria-street, judging the diffusion by the size of the apparent patch of light for a given distance between the arc and the glass, and measuring the absorption with a photometer. The practical difficulty which arises with all kinds of prismatic glass is that of cleaning it. This is found to be a most serious obstacle to the outdoor use of glass specially designed for dealing with the light according to optical laws. Not only is an increased expense involved, but the settling of dust and dirt on and between the prisms obstructs the light to such an extent that the advantages which it may possess when clean are soon lost. Hitherto we have been speaking merely of diffusion of the light for the purpose of softening shadows and diminishing dazzling. No attempt is made to equalise the distribution of the light, except by placing the lamps at a considerable height, and this is probably better, under the circumstances, than any use of prisms or reflectors. We are inclined to think that the effect would be much better if the mean position of the arcs were 9 or 10in. higher in the lantern. This, with a Brush lamp, would entail an alteration in the hood, and might make the lantern look a little top-heavy. Rays above the horizontal are very little use; but at present the top of the glass is at an elevation of some 45 degrees above the arc.

Columns of various heights have been tried. We noticed the other day that the leads were carried outside from one of the lanterns, and it was not until we examined it closely that we found that the shaft, which was painted green to match the pedestal, was only a scaffold pole, used for the purpose of experimenting as to the best height. The difficulty of using a long ladder (since the idea of lowering the lamps for trimming is out of the question) has been got over by providing sliding steps, which can be pulled out on alternate sides, the lowest being about 8ft. from the ground. A short ladder only need thus be

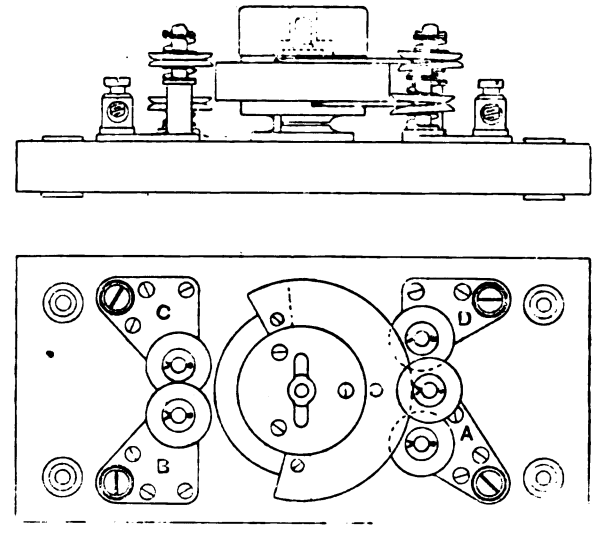

Fig. 2.—Short-circuiting Switch in the base of the Lamp-posts.

carried. In each pedestal is a switch, by which any lamp can be cut out without breaking the circuit. Fig. 2 shows a side and a front elevation of the switch. On a wooden cylinder are mounted two sectors of sheet brass, the lower one being semicircular, and the upper projecting a little beyond. These discs pass between bevelled washers, which are pressed together by springs. The current passes from A to B, and returns, after going through the lamp, from

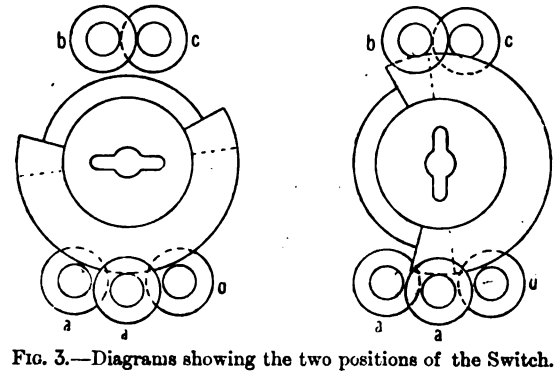

Fig. 3.—Diagrams showing the two positions of the Switch.

C to D. In Fig. 3 the two positions are shown. The two sets of washers, *a a*, are connected to the same pole, one being on the level of the upper sector, and one on the level of the lower. In the right-hand diagram it will be seen that the upper washer, *a*, is connected to *b* by the upper sector, while *c* is connected to *d* by the lower one. On turning the switch, the lower sector makes contact with the lower washers, *a*, just before the upper sector breaks circuit at *b*. The lower washers, *a*, are, therefore, short-circuited with *d* by the lower sector, the lamp being cut out.

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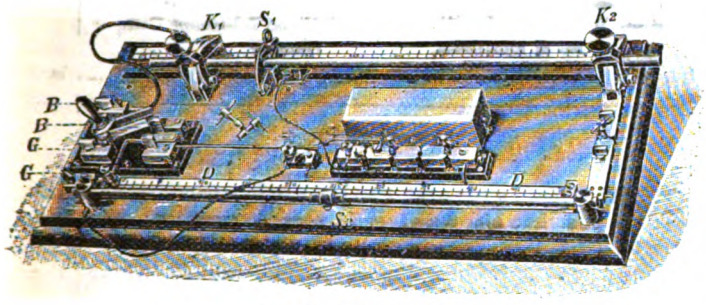
The streets of the districts allotted to the Brush Company will be lighted in all by 282 arc lamps of 2,000 nom. c.p., and by 600 incandescent lamps of varying candle-power in the smaller thoroughfares. The mains from the generating station at Bankside are at present laid across Southwark Bridge, but for the purposes of lighting the western division the mains will be laid from the generating station across Blackfriars Bridge. The station of the Brush Company has a capacity of 880 2,000 c.p. arc lamps and 240,000 incandescent lamps of 8 c.p.

THE FRANKFORT EXHIBITION.—IV.

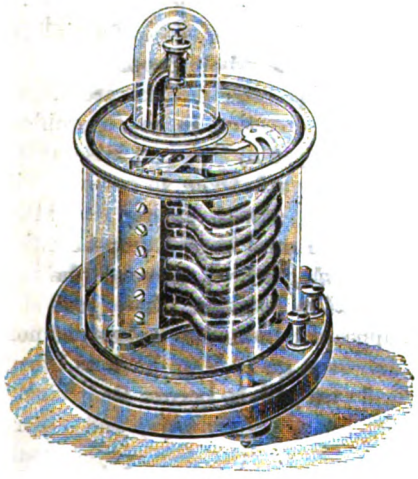
(FROM OUR SPECIAL CORRESPONDENT).

The Hartmann and Braun collection of instruments is especially worthy of notice, and contains, amongst other things, a low resistance bridge, a new form of Deprez's galvanometer, and Braun's electric pyrometer. The bridge for measuring low resistances is a modification of the Wheatstone bridge, in which contact resistances by means of double readings are eliminated.



Low Resistance Bridge.

Two clamps, K_1, K_2, are provided, which will hold rods or wires of any section, and will grip lengths up to 21in., the length of the conducting material measured being read off on a scale. Between G and G is the mirror galvanometer, and several constant cells between B and B. Two bridge plugs, such as 10 and 100, are withdrawn, and the movable contact S_1 is brought near to K_1, and afterwards near to K_2, the balance of the galvanometer being restored in each case by the adjustment of the

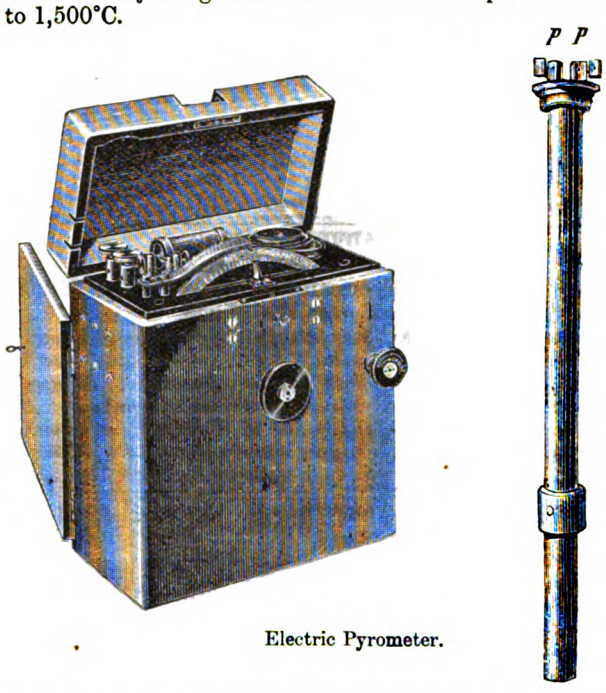


Deprez Galvanometer.

contact S_2. The resistance between the two positions of S_1 is thus measured by a comparison of the fall of potential with the fall of potential over the calibrated wire D. Errors due to the contact resistances are thus avoided. The instrument is provided with a double switch to complete the battery and galvanometer circuits in succession.

The new form of Deprez's galvanometer differs from the original in some notable respects. It has six strong horseshoe magnets, placed horizontally one above the other, and having common pole pieces. By this means a powerful, constant, uniform field is produced, and great sensitiveness attained. There is a metal torsion suspension at the top, and a silk fibre at the bottom of the coil to keep it in position, the former constituting one connection of the coil, the circuit being completed by a delicate spiral at the bottom. The sensitiveness thus lost by the use of the spiral is just half that of the ordinary Deprez instrument with two metal suspensions. The galvanometer has effective air damping, and is little affected by external magnetic fields. This firm is well known in Germany, particularly from its ammeters and voltmeters, their clear and large reading scales giving these instruments additional value.

Braun's pyrometer has for principle the variation of the resistance of a wire of platinum with the temperature. The instrument is neatly carried out and seems capable of considerable sensibility even at the high readings; it consists of a fireproof tube into which the platinum wire, non-inductively wound, is mounted. The ends are connected with the clamps P and P. A solid oak case is arranged to hold dry cells, which are introduced through a door at the back. They are connected with telephone or mirror galvanometer, and the wire on the revolving wheel, together with the platinum wire, the resistance of which is wanted, are arranged as a Wheatstone bridge; the scale on the adjusting wheel reads off the temperature direct up to 1,500°C.



Electric Pyrometer.

As, of course, the distance of the pyrometer from the bridge is immaterial so long as conductors of very small resistance are used, the instrument may be called a telepyrometer, and temperatures of furnaces, &c., read off from a distance. The chief merit of the arrangement is its portability.

Faraday Centenary Lectures.—Prof. Dewar delivered the second of the Faraday centenary lectures at the Royal Institution, on Friday evening, the Duke of Northumberland occupying the chair. The lecture was devoted mainly to the achievements of Faraday in chemical science, as that of Lord Rayleigh's last week was to his physical researches, and was illustrated and explained by experiments, which were performed with admirable success. The principal feature of the lecture was the production of liquid oxygen, which was exhibited boiling at a temperature of about – 200 degrees C., or nearly 400 degrees below the freezing point of Fahrenheit. This result was achieved by the combination of exceedingly low temperatures, produced, in this instance, by ethylene and enormous pressure, and was one which, so far back as 1845, Faraday hoped to attain. A vote of thanks was accorded to Prof. Dewar, on the motion of the Lord Chancellor, seconded by Sir Lyon Playfair, who referred to the fact that Prof. Dewar was his pupil in chemistry.

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STREET LIGHTING.

Street paving, street lighting, and street decoration are among the works which are carried out for the convenience and enjoyment of the whole community, at an expense which is largely, if not almost entirely, borne by the wealthier classes. The refinements of civilisation, prompted by motives of self-interest, are introduced in the first instance for their own gratification by those who appreciate them, but, as the luxuries of one age become the necessities of the next, these refinements, in a well developed state of society, overflow their source, and extend to the whole people. The street decoration provided by ancient and modern architecture, and culminating in another direction in the magnificent flowers in our parks, may be enjoyed by the most miserable vagrant, who contributes nothing towards them, in common with the largest ratepayer of the day. Street paving has attained a high degree of excellence in most large European cities, and to this electric lighting is being added, although the reverse order of things is to be found in America, where good street paving, if not unknown, appears to be neither understood nor appreciated. We need not, however, go to New York to learn how to light our streets, nor do we wish to borrow their elevated railroads, phonographs, trolley-wire tramways, and other products of transatlantic civilisation. If the ratepayers really want electric light in their streets, it can be provided with the greatest ease.

The appliances and means for lighting seem to have a picturesqueness and beauty which are inverse to their efficiency and power. The lamps of Pompeii probably yielded as small a candle-power as any lamp could give, but have never been surpassed for grace. The beautiful iron lanterns of north Italy were intended to light the entrances to the palaces rather than afford illumination for the passers by, and the

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old torch holders remind us that those who had to be abroad after nightfall generally used a torch, the oldest form of light, as is indicated by the etymology of the word lamp. A few torch-holders, and many torch extinguishers, are to be found to-day on the ironwork of gates and railings in London, and here and there a ring which once held an oil lamp. Such lighting sufficed for the requirements of the time; indeed, we are informed by an eye-witness that Grosvenor-square and St. James's-square were "very handsomely lighted" by oil lamps, which were daily removed, trimmed, and replaced by porters, who trundled them through the streets in barrels. There are a good many small towns to-day which, either having no gas, or having quarrelled with the price charged for street lighting, still content themselves with the smoky twinkle of the oil flame. A general illumination of the streets in the old days was only to be seen on rare occasions of public rejoicing, when everybody set a light in his window, and testified to his festivity by a homely display, but one which showed more sympathy and feeling for the festival than the flaming devices of gas-pipe and gaudy glass-work which are hired at so much a night for our modern jubilees.

When, after sundry experiments at Birmingham and Salford, gas lighting was introduced in London in 1813, it was first seen on Westminster bridge, and immediately after made rapid progress. For no purpose was it better adapted than for street lighting, and, unlike electrical illumination, it was extensively employed for public lamps from its earliest days. The change was not revolutionary, for there was no prodigality of lamps, and the same old square lanterns have been used in many London streets with but little alteration. To-day such old-fashioned contrivances suffice for the lighting of that part of Piccadilly which runs along the park, one of the most characteristic streets of London, and at this time of the year one of the most attractive. The lamps are a little closer together than in less important thoroughfares, but the illumination *as* illumination, for the purpose of reading a newspaper or finding a fallen sixpence, is of the feeblest kind. The double row of lights just serves to trace the route ahead, as a channel is marked by buoys. At Hyde Park Corner we have, perhaps, the best bit of street lighting in London, and it seems to be effected at a most disproportionate cost. The only idea is to bunch a number of gas burners together in a glazed furnace, for the regenerative and other novel burners in which some originality was attempted have long ago disappeared. Market-street, Manchester, is well lit, but the lighting, like that of many thoroughfares, is largely assisted by the shops. The opinion has been expressed by many people who have visited the United States that the street lighting, which is considered in that country to be so necessary, is not altogether ornamental or practically useful. Our American visitors are always astonished at the gloom of our streets, and we do not hesitate for a moment to say that an increased light is necessary; but it is necessary that the use of arc lights in the City should be extended with caution.

Ten years and two months have elapsed since, on April 1, 1881, the streets from London-bridge to Blackfriars, St. Paul's Churchyard, Cheapside, including both open spaces, and narrow thoroughfares were lit by what were then called the "Siemens system" and the "Brush system." High lattice posts supported clear glass globes at such a height above the pavement that it was fondly hoped that the atmosphere, about the transparency of which we so often complain, would tone down the shadows and subdue the glare. Unfortunately, the very contrary was found, and when, after many troubles, the premature attempt was abandoned, little or no effort was made by the contractors to renew the work, for it was not remunerative, and the public, so far from finding that they could not do without it, have almost forgotten that they ever enjoyed it, and it is only remembered as a rather unpleasant combination of flickering glare and exaggerated shadows. The causes of the sudden extinctions, both total and local, were recorded in our columns, and were due to the breaking of driving belts or of governors, the slipping of brushes from their holders, and of carbons from their rods; and one or two cases of faulty insulation added to the many troubles which beset the work. Where the light was valuable and was duly appreciated, it has been used continuously during these past ten years—at the British Museum, and at Charing-cross and other stations. The inscrutable workings of Fate, operating in conjunction with the hardly less intelligible doings of the Commissioners of Sewers, have so ordered matters that the revival of street-lighting by electricity should fall at the summer solstice, and it follows that he who would criticise the result must make a special expedition to Queen Victoria-street, unless he be among those few stragglers who are detained there after night-fall. Such a special journey will be undertaken by but few enthusiasts, or by those, who, like ourselves, have treated it as a matter of duty. The result, which is dealt with in detail in another column, appears not only to be satisfactory but to have an air of permanence about it, which says that it has come to stay.

No part of London is so well paved, kept in such first-rate repair, so carefully cleaned in the small hours of the night, and generally looked after, as the City. The vestries, with their petty squabbles, and constant endeavours to make the rates go as far as possible, and to throw their burdens on to other shoulders, look after the streets with varying success. None of them have attempted to light their thoroughfares by electric light as yet, and we doubt whether the ratepayers would sanction the expense. In the meantime, we shall have an excellent opportunity of judging the comfort and usefulness of arc lighting, as shown in the City, and the details as to the height of the posts and the current required; and there can be but little doubt that while nineteen Londoners out of twenty are at present quite satisfied with the lighting of the streets by gas, they will gradually be convinced that an illumination ten times greater than that which they now have, is absolutely indispensable to their convenience and safety.

OBITUARY.

PROFESSOR WILHELM WEBER.

By the death of Professor Wilhelm Edouard Weber, at Göttingen, at the age of 87, we have lost the second of the great trio, Gauss, Weber, and Thomson, who were the architects of the electro-magnetic system of measurement which has been of such incalculable value to the practical electrician.

In the year 1833 Gauss first published his theory of an absolute system of magnetic measurement, and, in 1851, Weber, who had been associated with Gauss in his magnetic measurements, promulgated the first definite system of electric current measurement in terms of absolute units, and henceforth a large proportion of his time and energy were devoted to the development of the system, which was introduced into this country and further developed by the labours of Sir William Thomson and of the British Association Committee on Electrical Standards, appointed at his suggestion in 1861.

Weber and Gauss conjointly established, in 1833, an electric telegraph worked by a voltaic battery, and subsequently by a magneto-electric machine devised by Steinheil, for transmitting signals between the University of Göttingen and their own magnetic observatory. This telegraphic line is of special interest owing to the fact that the receiving instrument was

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practically identical with what is now known as Sir William Thomson's galvanometer, having been re-invented by him.

The greater part of Weber's work, however, was in close relation with the working out of the electro-magnetic measurement of electric currents, as in the case of his invention of the electro-dynamometer, now so extensively used in the numerous forms which it has assumed to meet the various requirements of the electrical engineer.

Weber's attempt to explain the phenomena of electric current induction by means of an electrostatic repulsion between moving particles carrying electric charges formed a portion of his researches on the electro-magnetic measurement of electric currents, published in 1864 and subsequent years under the title of "Elektrodynamische Maasbestimmungen," in the "Abhandlungen der Math. Phys. Classe der königlichen Sachsischen Gesellschaft der Wissenschaften." Helmholtz showed that Weber's formula led, in certain cases, to impossible results, but Prof. Lindmann, in 1884, showed that certain assumptions as to the nature of the molecules of matter led to Weber's formula, so long as the relative velocity of the particles does not exceed the velocity of light, but when this critical value is exceeded the law no longer holds, and in this form it is not open to Helmholtz's objection.

Weber's well-known theory of magnetic induction was another contribution to electrical science of which it would be difficult to exaggerate the importance, for, although in the light of our present knowledge it is in many respects inadequate, it undoubtedly formed the basis upon which a theory of magnetic induction is being gradually built up.

THE HISTORICAL DEVELOPMENT OF THE INDUCTION COIL AND TRANSFORMER.

BY DR. J. A. FLEMING, M.A.

(Continued from page 213.)

In Silliman's Journal of Science, Page made some very excellent remarks upon the action of "closed circuits" in preventing or reducing the inductive action of the primary current upon the secondary circuit. He states that if a closed circuit, such as a metallic sheath or tube, is interposed between the primary or secondary circuits, it more or less annuls the inductive action of the former on the latter. He hence notes that wrapping, what he calls a "compound magnet," *i.e.*, an induction coil with two separate circuits, in a metallic sheath, greatly reduces the inductive action of the primary on the secondary, although it does not prevent the action of the primary circuit in permanently magnetising the core. The same action he points out proves prejudicial if bobbins, made of metal, or having metal cheeks, are used upon which to wind the circuits of the coil. Hence, bobbins for induction coils should be made entirely of non-conducting material.

We also find that in 1840, J. H. Abbot, of Boston, U.S.A., constructed a large induction coil (see *Silliman's American Journal of Science*, Vol. XL., April, 1841, p. 107), which was capable of charging a Leyden jar, and which gave small secondary sparks. The break was a hand-worked break (*see* Fig. 16*a*). The secondary terminals were described as being luminous in the dark when the coil was in action. This coil was modelled on Page's.

It is evident from the foregoing that, even in the year 1838, C. G. Page had brought the induction coil to a high degree of perfection by his researches made at Salem and at Washington, and in particular had shown that the secondary circuit could exhibit effects of "tension" and produce electrostatic change in conductors having capacity connected with them when induction coils were used in which the secondary currents consisted of great lengths of fine wire. He had obtained sparks in air from the secondary terminals of coils, and shown the conditions under which these "electrostatic" effects could be exalted. We must also credit him with being an independent inventor of the self-acting hammer electro-magnetic contact breaker.

Continuing his researches, Page made many coils between 1838 and 1850, having highly insulated secondary circuits and vibrating automatic contact breakers. He found, as above observed, that he could charge Leyden jars, diverge the gold leaves of electroscopes, and produce many of the effects hitherto only obtained with electrostatic machines by means of these induction coils. With one of his coils he found he could obtain sparks half an inch long in air from the secondary terminals. He noted, also, the effect of rarefying the air round these terminals on the length of discharge. With one coil, which gave a secondary spark of $\frac{1}{16}$th of an inch in air, he obtained a

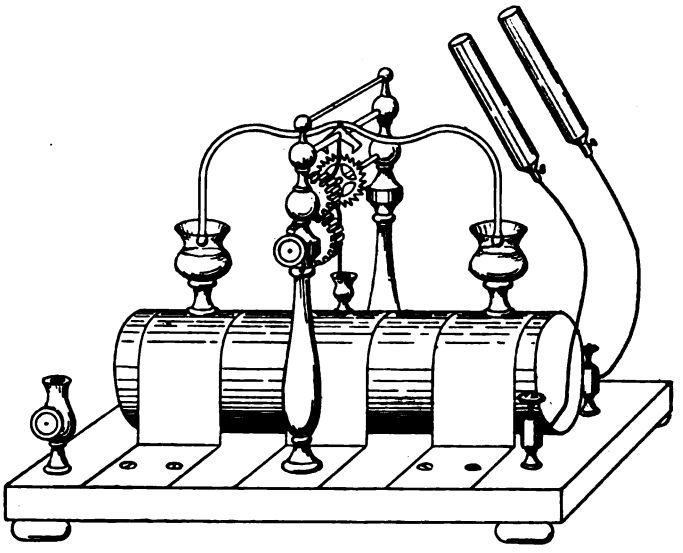

FIG. 16A.—Abbot's Induction Coil (1840).

discharge of about 4½ inches in rarefied air, when the primary circuit was actuated by one single Grove's cell. In 1850 Page constructed a very large coil, of which the primary circuit was a wire or ribbon of copper, one quarter of an inch in diameter. This coil, when worked by 100 Grove's cells, gave sparks from the secondary circuit 8 inches in length.

One striking peculiarity about this large primary coil attracted Dr. Page's notice. When a solid iron core was put into this great helix the primary current took a very sensible fraction of a second to rise to its full value; from $\frac{1}{10}$th to two

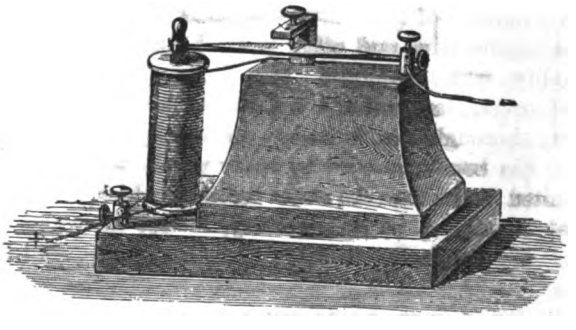

FIG. 17.—Wagner's Automatic Contact Breaker.

seconds, according to the position of the iron core. Page also noted a phenomenon, afterwards recorded by Rhyke in 1855, viz., that when the primary circuit was broken just between the poles of a powerful magnet the break-spark was extinguished with a loud explosion, like that of a pistol when fired.*

§ 10. Wagner and Neef's Automatic Contact Breaker.—Continental writers generally attribute the invention of the automatic vibrating electro-magnetic contact breaker to J. P.

* The greater part of Dr. C. G. Page's valuable work is recorded in his own Papers, published in *Silliman's American Journal of Science* between 1834 and 1850. He published in 1867 a *brochure* entitled the *History of Induction*, which is alluded to by Du Moncel in his work (Vol. II.) *Exposé des Applications de l'Electricité*, but this pamphlet of Page's is not to be found either in the British Museum Library or in the English Patent Office Library.

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Wagner* and to Neef.† These inventors improved upon Page's mercurial break by constructing the vibrating armature with platinum contacts in the form in which it is now used in every trembling electric bell. The apparatus is too well known to need description. A form of Wagner's hammer, as it is generally called, is shown in Fig. 17, intended as an interrupter to the primary circuit of a coil. Du Moncel, however, states that MacGauley, of Dublin, independently invented the form of hammer contact as now used. From this date onwards it has generally been the custom to interrupt the primary circuit of an induction coil, if small, in the manner introduced by Page in 1838, viz., employing the intermittent magnetism

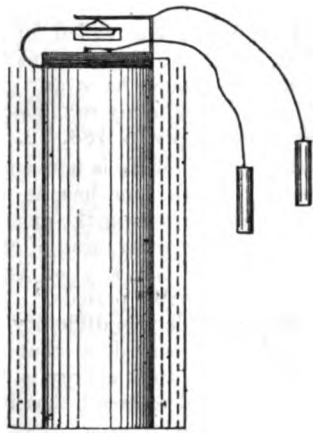

FIG. 18.—Wright's Coil and Contact Breaker.

of the soft iron core of the coil to work the vibrating hammer of the break, using, however, the platinum contacts of MacGauley or Wagner instead of Page's mercurial cup. On the other hand, when the coil is large, the break is usually made as a separate piece of apparatus with independent magnet, and in that case it is often found best to revert to the mercury cup break of Page, and cover, as he did, the surface of the mercury with oil or alcohol to prevent oxidation, as was done subsequently by Ruhmkorff and others. As is usually the case, useful improvements are invented several times over by inventors who are not familiar with what has already been

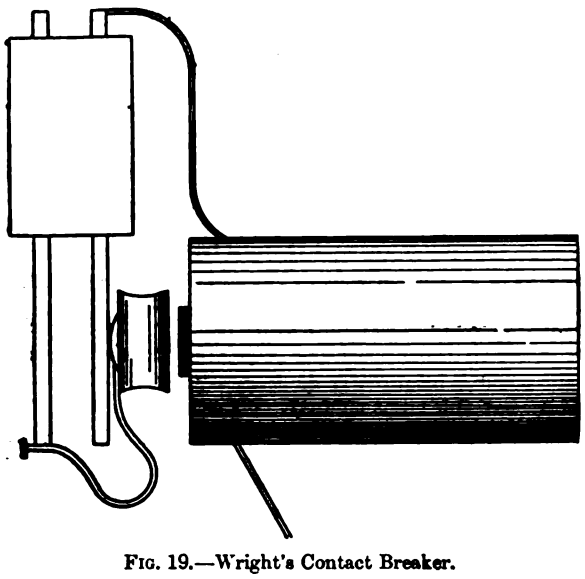

FIG. 19.—Wright's Contact Breaker.

done. We find in Sturgeon's *Annals of Electricity*, Vol. V., p. 30, a description of a coil by Thomas Wright, of Knutsford, dated 1840, in which he gives a sketch of a neat form of vibrating contact breaker (*see* Figs. 18 and 19), which is practically the same as that used on all small coils at present. Wright followed Neef and Wagner in suggesting that the contact points should be tipped with platinum. He succeeded in making some "electrotomes," as they were called, in which the spring vibrated so fast as to give out a musical note. Wright also gives details of many coils made by him about this time to determine the best dimensions of the core and of the circuits. It will be seen that by the year 1840 the induction coil had been practically completed in all essential parts, with the exception of the condenser. The separate primary and secondary circuits of thick and thin wire, the divided iron core and the vibrating contact breaker had been arrrived at and perfected; chiefly by the investigations of Callan, C. G. Page, Sturgeon, Backhoffner, Wagner, and Neef.

§ 11. **The Researches of Masson and Breguet.**—Between 1838 and 1842 the French physicists, MM. Masson and Breguet, prosecuted researches of a valuable character on the induction of electric currents. In the *Annales de Chimie et de Physique* (3rd Series, Vol. IV., 1842, page 129) will be found a long memoir, summing up the results of their work, which was communicated to the Academy of Sciences on August 23rd, 1841.

This Paper contains an account of very careful experiments on the production of electrostatic effects by secondary induced currents. In their investigations, Masson and Breguet employed a toothed wheel interrupter, or rheotrope, consisting of a brass toothed wheel having the teeth interspaces filled up with wood or ivory; one or more such wheels could be revolved on the same axis, and, by means of springs pressing against the periphery of the wheels, the primary current could be broken, and the secondary circuit closed at instants corresponding to the closing or opening of the primary circuit.

By the help of this apparatus they could separate out the two induced currents, and by means of a condenser and electroscope they examined the electrostatic potential at various points on the secondary circuit. Not being aware of the previous researches of Page, these investigators were apparently under the impression that they were the first to show that a condenser could be charged from the ends of the secondary circuit. Transforming, as they called it, induced currents into static electricity, they produced luminous discharges in vacuo by means of induced currents, and showed that these discharges had all the characters of discharges produced by electrical machines or Leyden jars. These results surprised European physicists, who, as Du Moncel observes, were apparently not aware that similar experiments had already been conducted in America. Amongst the chief results of this investigation was the experimental confirmation of the fact that the two secondary induced currents, the one produced by the commencement of the primary current, and the other produced by its cessation, consisted of equal quantities of electricity set flowing in opposite directions. Also the other important fact that the maximum value of the electromotive force of the secondary current at break of the primary is much greater than the maximum value of the secondary current at the starting of the primary, was stated by them. Hence it became clear that the direct or break-induced secondary current could traverse air spaces or overcome resistance which was impossible in the case of the inverse or make-induced current. The researches of Masson and Breguet established on a quantitative basis more firmly than before the facts of the induction of electric currents, but they did not achieve more than had previously been done in exalting the spark-producing power of secondary coils.

§ 12. **Henley's Coil.**—In the years between 1842 and 1851 very little progress appears to have been made in improving induction coils. Some modifications of arrangement either of the coil or the contact breaker were introduced. To this period, probably, belong two such varieties which are mentioned and described by Noad (*Manual of Electricity*, Vol. II.). One of these is represented in Fig. 20. The primary coil consisted of about 35ft. of insulated copper wire (No. 21), and the secondary of 1,400ft. of silk-covered copper wire (No. 20). The battery contact is renewed and broken by the rotation of the soft iron bar, which, mounted between two brass supports, is situated immediately over the axis of the coil, in which is placed a bundle of iron wires. The current from the battery passes through the support and the axis carrying the iron bar;

* See *Pogg. Annalen*, Vol. XLVI., p. 107, 1839; † and *Pogg. Annalen*, Vol. XLVI., p. 104, 1839; and compare *Wiedemann's Galvanismus*, §§ 696 and 737.

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and the contact is interrupted by the small steel point, dipping as the bar revolves into and out of the mercury contained in the brass cup mounted on the brass pillar, through which the circuit is complete. This apparatus formed a self-acting shocking coil, but could produce no sparks from the secondary. Noad describes also an interesting form of coil which bears some relation to Page's electro-magnetic multiplier, and which, Noad says, was given to him by Mr. W. T. Henley. It is represented in Fig 21. A series of U-shaped bars of soft iron bolted

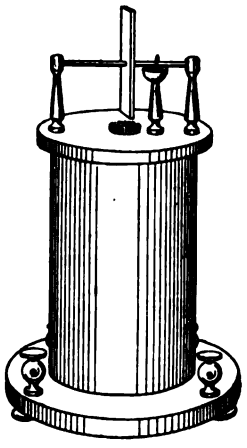

Fig. 20.

down to a base board was wound with four coils of No. 14 covered copper wire, to within an inch of either extremity. Over this was wound 1,000 yards of No. 34 silk-covered wire in one continuous length. A revolving iron armature rotates on a vertical spindle, so that in passing over the magnetic poles it nearly completes the magnetic circuit. The contact breaker consists of a bent lever, one end of which dips in a mercury cup and is so pivoted that the motion of the other end against the undulating surface of a cam-wheel attached to the spindle serves to dip the first-named end in and

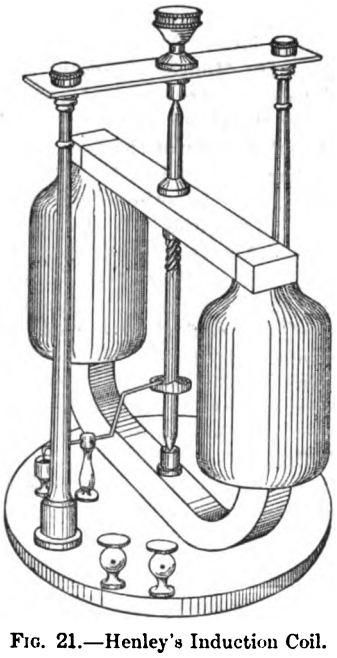

Fig. 21.—Henley's Induction Coil.

out of the mercury. The break of the primary circuit is so adjusted as to take place just after the soft iron armature has completed the magnetic circuit. Actuated with a battery of 10 cells this coil gave sparks one-eighth of an inch long in air, and remarkable for their quantity. It is easily seen that the appliance is, at the same time, an induction coil and also an electro-magnetic motor, and that a suitable arrangement of the time of making and breaking the primary circuit will cause the soft iron armature to be kept continuously in motion. It was noted as a curious fact that when the ends of the secondary circuit were metallically joined the spark at the primary break was much reduced. This is obviously due to the fact that the closing of the secondary circuit reduces the self-induction of the primary coil. These pieces of apparatus formed no real advance on what had been done before.

(To be continued.)

ELECTRIC AND MAGNETIC THEORIES.

BY SILVANUS P. THOMPSON, F.R.S.

§ 1. As Mr. Sprague has called in question the method of my argument, which I took the pains to explain beforehand in § 2, so that no one should have any ground to accuse me for laying a pitfall, I begin my rejoinder by quoting a few lines from Mr. Sprague's reply, p. 188, § 2.

"The real point in debate is how energy is transferred by an electric *current*. I ask him, has he *any evidence* of a single case of lateral transfer during the existence of true current? It is notorious that there is no scrap of evidence."

"He has dealt (in the way of evidence) solely with the phenomena of the variable periods."

"Therefore he avoids this difficulty by a logical dodge. He says, practically, if I can show that there are *some* cases in which we must agree that energy is transferred through the medium, I am entitled to assert that it is so in all cases. Bad logic and worse science."

Now, without admitting for a moment that I resorted to any "logical dodge," or argued with bad logic and worse science, I will at once say that I entirely agree with the first four sentences that I have quoted. There is *no evidence* (and I said as much on p. 44) *during the steady flow of the current* that the energy is transferred *laterally* across the medium. Neither is there any evidence during the steady flow that the energy is transferred along the wire *longitudinally*. The simple fact is that the current in the case of unvarying flow gives *no evidence at all* of the mode of propagation of the energy, and, therefore, in the present state of science affords no basis for an argument either way, in favour of lateral propagation or in favour of longitudinal.

Under these circumstances what can we do, in default of any crucial proof, to discover how the energy is propagated? The only course is that which in every branch of every science has proved the key to discovery, namely, argue forward from the known to the unknown. Find a case in which direct evidence exists, and argue on from this to those cases in which we have not yet been able to find direct evidence. If this procedure is to be stigmatised as a "logical dodge" then I fear that most of the advances of science during the last century must be set down as the result of logical dodges also. To argue from the known to the unknown, and then to test the result by probing to the bottom the necessary consequences of the step, is the one true scientific course in such a dilemma.

What did I say at the outset, on page 44? "Since in those cases in which the hypothesis of lateral transfer cannot in the present science be directly demonstrated, there is no evidence to show that the transfer takes place in any other way, then *in the absence of such evidence* one is logically driven to the conclusion that in all cases the mode of transfer is the same as in those cases in which a direct demonstration is possible." Is not that simply a statement that I proposed to argue from the known and demonstrable to the unknown and yet undemonstrated? A "dodge" it is not; it is a legitimate proceeding, both logical and scientific.

§ 2. Mr. Sprague denies the legitimacy of arguing from the cases of variable currents to that of steady currents. He virtually says that, when looking for evidence of the invisible mechanism by which a current is sustained, we have no business to regard any evidence derived from altering the strength of the current. Why does he lay down any such short-sighted limitation? If I want to find out whether a leak of gas comes from a certain pipe, must I refuse to make such

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simple experiments as turning off the main supply, or turning it on more fully? To tell me that I am not to apply any evidence except that derived from considering the gas supply in its steady state is absurd. There are many things in science which in order to measure them *must* be changed. How can you find out the energy of rotation of a spinning body except by changing the rate of its rotation? To tell me that I am, in considering the problem, to be debarred from any evidence that is based upon altering its rate of rotation, is an insult to common sense.

I fail to see why, Mr. Sprague, reject, refuse, and exclude as irrelevant the overwhelming evidence that when the current is being varied the energy which propels that current comes in laterally from the medium.

§ 3. Mr. Sprague has fallen into a serious misunderstanding of the cases presented by me in Figs. 1 to 5. I have never said, or suggested, that in Fig. 1 (or any other of the figures) the energy travelled from the source S *along the wire* to the primary coil A in order thence to travel across the medium to B. In order not to confuse the issue then under discussion, I expressly said nothing in the description of that figure as to the precise mode in which the energy travelled from S to A. My point was that, however it got to A, which I was not then discussing, it undoubtedly and beyond cavil passed from A to B by the medium. So § 5 of Mr. Sprague's reply, on p. 188, is founded on a misconception. In § 6 he proceeds to argue that in these very cases the energy flows across the medium along the magnetic lines; and he proceeds (to use his own elegant phrase) to "knock the bottom out of my tambourine" by informing me that the magnetism accounts for it all. Well, but unfortunately the energy moves, as can be directly demonstrated on even Mr. Sprague's views, to say nothing of mine, transversely to the magnetic lines, not along them. Else how does the energy get from a coil surrounding a bar of iron that lies in its axis? And, moreover, the magnetic lines in the medium are a part of the physical properties of that medium, and have no existence apart from it. And the energy paths in the medium are, after all, just as real entities as the magnetic lines are, though not so familiar to us.

§ 4. Time was when we did not know how to prove the paths of the magnetic forces in a medium: the iron filings experiment is now most familiar. Time was when we did not know how to show the paths of flow of electric current in a sheet of tinfoil: this also is now a matter of simple experiment. Time was when we were ignorant of the paths of the lines of electrostatic stress in a dielectric; but Faraday showed us how to explore them with bits of silk in turpentine; Maxwell with suspended threads; Kerr by their action on polarised light. Even now some people can't see the evidence for them, or don't understand it; and time was when we did not even know that there were any energy paths, much less learned their direction. We know that direction now in general terms, but we are as yet ignorant of any experimental mode of demonstrating them. I observe that, in § 15, p. 190, Mr. Sprague blandly suggests to me that I should "prove" their existence by applying polarised light to a pan containing bisulphide of carbon. That experiment would be about as useful as it would be to explore a magnetic field with bits of silk in turpentine, or to measure the brightness of a light by listening to it through a stethoscope. The experimental method of observing the energy paths in the case of steady flow has yet to be discovered. At present, we can only argue from the known to the unknown. By the way, it seems to me that Mr. Sprague must be confusing the energy paths with the electrostatic lines of stress, for it is the latter which produce optical phenomena in polarised light.

§ 5. Many of Mr. Sprague's replies are mere inversions of previous argument: for example, §§ 7, 8, 9. These and others equally inconclusive I must pass by, to come to more vital matters, ere my allotted space be filled up.

§ 6. In § 13, p. 190, Mr. Sprague asks me about Fig. 8, and the energy paths from source to sink. He suggests that if the part 5—6 on the wire is the "sink" for the energy from the part 5—6 of the "source," the transfer of energy between these parts should go on equally well if the other parts were cut out. I also say, why not? Cut out the parts below 5, 5, by immersing all the lower part in quicksilver, and I say that even then the energy will still flow across from 5-6 in the "source" to 5-6 on the "sink," independently of the other parts.

§ 7. In § 20 Mr. Sprague suggests to cut off the flow of energy in my Fig. 9, by surrounding the central wire with a "total reflector" of energy. As a total reflector of energy is yet undiscovered in science, I am unable to comply with the request. One other thing he omits in that paragraph. If a screen or reflector—I suppose he means a metal tube—were put around the central wire its presence would alter the energy paths, not cut them off. For he forgets that the energy paths are always in the equipotential electrostatic surfaces.

§ 8. In § 18, p. 218, Mr. Sprague remarks that the term "end-thrust" is not his term at all. I am not sure whose the term may be; the essential idea is his. His turbine which propels the water in his hydraulic diagram certainly works by end-thrust. He says also, on p. 218, that he has nowhere suggested that what we call electric current is a motion of translation. Then why the turbine or the pipes? What can be more emphatic than Mr. Sprague's dictum:—"I say that the conditions of the electric current and the hydraulic current are identical in principle"? He speaks (p. 575) of "drawing in the water at one end and forcing it out at the other," and calls this "the most perfect analogue" to an electric current. That is perfectly clear and plain—at least I thought so. Accordingly, I showed that this most perfect analogue, which certainly works by end-thrust, produces stream-lines quite different in form from those of the electric current. This was a plain piece of evidence that the perfect analogue was a false analogue. Yet now it appears, from § 18, p. 218, that Mr. Sprague repudiates his former proposition, and says that he has never said that there was any end-thrust, or any actual transfer along the pipe (*i.e.*, motion of translation). Well, then, if there is not to be any transfer along the pipe by end-thrust, and if the pipes which, on p. 730, are called elastic pipes are now not to be elastic (for I observe that when I ask about this "perfect analogue," whether the copper conductors of an electric current swell up or contract, Mr. Sprague resents the query as not being "criticism"), what becomes of the perfect analogue? I fear the perfect analogue has landed its author in a mass of contradictory conditions.

§ 9. Last of all, why does Mr. Sprague persistently ignore the Hertz experiments? Does he not like direct evidence? "I am not going to be led off into Hertz experiments just now," he says. Precisely so. He ignores the most striking evidence that electric energy can be, and is, conveyed by the medium. That is where we differ. He declines to discuss the evidence that points with overwhelming certainty to the imperfection of the views he advocates. It is really no affair of mine if Mr. Sprague chooses to put aside, as though of no importance, the experimental work of Hertz. By so doing his own position is weakened far more than by anything that I have written, or could write. Mr. Sprague is quite welcome to have the last word in this discussion, even if that word be to say that in Hertz's experiments there is not a steady-flowing current but only oscillations of currents. The evidence exists: the only real question left is whether we will close our eyes and ears and shut it out, lest it should afford a basis for arguing from the known to the unknown.

ON THE MECHANICAL ACTIONS OF ELECTRICAL WAVES PROPAGATED IN CONDUCTORS.*

BY H. HERTZ.

The study of the forces to which a conductor is subjected when placed in the path of a series of electrical waves, seems to me interesting for many reasons; among others, because these forces, when strong enough to be observed, enable us to study the waves quantitatively. I hoped to find in the nature and distribution of the mechanical forces a means of showing the existence of the magnetic force at the same time as that of the electric force.

* Translated from *La Lumière Electrique*, March 28, 1891.

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In all the experiments hitherto made, the electric force alone has been manifested†, and as ordinary means do not demonstrate the magnetic force, it is of interest to study new methods with this purpose in view. I had an additional motive which formed the special aim of my research, and this arose from my hope of making observations of the waves in air under circumstances in which the movements produced could not be in any way attributed to forces acting at a distance. Owing, however, to the feebleness of the actions produced under these circumstances, I have failed in this endeavour, and have been forced to content myself with the study of the waves propagated in wires, although in so doing the principal interest of the experiments disappears. The mechanical action of waves propagated in wires can be attributed to the attractions of the quantities of electricity which accumulate on the wires, and to the currents which flow within them, and experiments made on these waves cannot thus serve as a crucial test between the old and new modes of regarding the phenomena.

The System of Waves Employed.

After having studied various dispositions of apparatus, and obtained results which were quite concordant as regards the principal points at issue, I resolved to adopt the method of Mr. Lecher as being the most appropriate. Fig. 1 indicates the form of the apparatus. A A′ is the primary conductor, formed of two square plates of 40 centimetres side, joined by a brass wire 60 centimetres long. This wire is interrupted in the middle of its length, where the spark gap is placed. A small induction coil is used as exciter, worked by two accumulators, and producing sparks four centimetres long. The simple discharge of this little coil is certainly less powerful than that of a larger one, but the rapidity of the discharges compensates for the defect.

Facing the plates A A′, at a distance of 10 centimetres, are the plates B B′ attached to two parallel wires B b, B′ b, placed at 10 centimetres from each other. These wires are each 6·8 metres long, and their ends are connected at $b\,b'$. At a distance B a, which is variable, the two wires are also connected by a bridge piece $a\,a'$. For a certain position of this bridge, at a distance of about 1·2 metres from B B′, a very energetic oscillation is produced at $a\,a'$ and $b\,b'$. This represents the half length of a stationary wave, and, as Mr. Lecher has shown, it is produced by resonance between this vibration itself and the primary vibration produced in the air, between A A′ on the one side and B $a\,a'$ B′ on the other. A displacement of the bridge augments the period of one of these vibrations, and at the same time diminishes that of the other, so that with this arrangement the proper position of the bridge is determined in a very precise way.

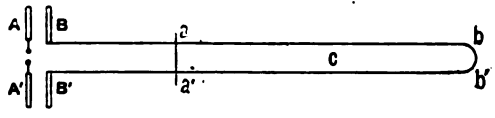

Fig. 1.

Besides these general advantages, the method also offers several special advantages for the purpose we have in view. As the forces to be observed are very small, it is necessary to carefully eliminate, as far as possible, all extraneous electrostatic actions due to the presence of conductors. This can be done with the disposition already indicated, as the wires, which it is necessary to bring near the bodies under test, form a system of continuous conductors. If in our experiments we surround the active parts with a metallic cage in connection with the nodal points $a\,a'$ and $b\,b'$ we shall protect them still more completely, without altering the vibrations.

As the conductors which we submitted in turn to the action of the forces did not, like the resonators previously used, choose a vibration of fixed period from among the oscillations produced, the results obtained, in the first instance, were confused, until care was taken to produce a simple oscillation, whose wave length was perfectly definite, and which had its nodes in a strictly determinate position. In the above arrangement this condition is satisfied, for no one can doubt that the points $a\,a'$ and $b\,b'$ are the nodes of all the vibrations produced, and that among these vibrations the slowest only are reinforced sufficiently to attain an appreciable intensity. The fact that we confine ourselves to the study of the half of a wave length does not in the least detract from the generality of the experiments. Finally, the vibration is of the same character whether the two wires are stretched out straight, or whether they lie near to one another, or curved in any way; just as the sonorous vibrations of air in tubes are the same whether the tubes are straight or bent.

We can thus easily make our vibration have all possible positions relatively to the body under test, although the latter is kept fixed. In fact, the relative positions in the experiments were always altered by moving the wires, even in cases where, for convenience, I speak as if the body under test had been moved.

† When I have formerly referred to the nodal points of the magnetic waves, it was only on theoretical grounds, and not from actual observation.

The Electric Force.

For the measurement of the mechanical action of the electric force, I have used a little cylindrical tube of gilt paper 5·5 centimetres long, and 0·7 centimetres in diameter. This tube was suspended horizontally by a thread of silk. A minute magnet was affixed for controlling purposes, and a small mirror was used to indicate the deflections. The entire system was suspended in a little glass box, and is indicated in Fig. 2. When it is submitted to the influence of the vibrations, the tube deviates and tends to set itself in the mean direction of the electrical force. To obtain greater deflections, I brought the two wires near together in the neighbourhood of the apparatus, and reinforced their effect near the extremities of the body tested by two small plates, as Fig. 2 indicates for a special case. Under these circumstances it was possible to obtain initial swings of over 100 scale divisions.

The regularity of these first swings was satisfactory, for on repeating the same experiment several times the results obtained did not differ from each other by more than a few per cent. As examples of the possibility of applying these deflections to purposes of measurement, I indicate two series of observations. The first shows the action of resonance. The apparatus was placed at c, the antinode of the vibration, and the wires $a\,b$ and $a'\,b'$ were brought near one another, as indicated in Fig. 2. The bridge piece $a\,a'$ was then placed at different distances e, measured from B B′, the induction coil was set working, and the value of i, the first

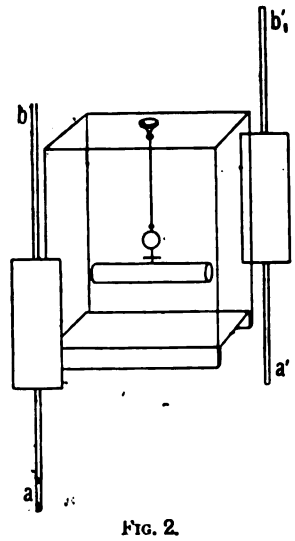

Fig. 2.

swing, was observed. The corresponding values of e and i in the neighbourhood of the maximum were as follow:—

e	8,	90,	100,	110,	120,	130,	140,	150, 160 cm.
c	5·3,	10·0,	21·8,	51·2,	44·1,	19·3,	10·3,	5·7, 4·2 divns.

If these values are plotted, the curve connecting them is quite regular, and shows a well marked maximum between 110 and 120 cm. As a matter of fact, the impulsive swing reached a maximum value, $i = 60·6$ divns., for $e = 114$ cm.

The second series of tests was made with the view of showing the diminution in the intensity of the vibrations from the antinode c to the node b. For this purpose, the distance between them was divided into 12 equal parts, and the apparatus was successively placed at the 13 points of division so obtained. The following observations were made:—

No. =	1	2	3	4	5	6	7
i =	80·5 ...	80·5 ...	79·0 ...	77·0 ...	65·0 ...	57·8 ...	50·0
No. =	8	9	10	11	12	13	
i =	38·5 ...	27·5 ...	17·5 ...	7·0 ...	1·0 ...	0	

These values vary in a sufficiently regular manner for the purpose of judging the form of the vibration, and for making it evident that it differs in a very noteworthy way from a simple sinusoidal oscillation.

Other experiments I have made show the direction of the electrical force in the neighbourhood of the wires. The results are only such as would have been expected. In the space between the wires the needle tends to set itself along the line forming the shortest distance between them. Outside this space the needle tends to set itself perpendicular to the nearest wire. The extremities of the little tube seem thus always to be attracted towards the nearest portion of the wires.

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The Magnetic Force.

For studying the magnetic force a circular ring of aluminium wire was used. The diameter of the ring was 65 millimetres, and that of the wire two millimetres. The ring was suspended so that it could turn about one of its diameters, and was furnished, like the cylinder previously mentioned, with a magnetic needle, a mirror, and a glass cage. Fig. 3 shows the arrangement of the apparatus.

If for a moment we disregard the magnetic forces which we know to exist, we should expect that the ring, under the influence of the oscillations, would behave like the cylinder already described ; and that the parts of the ring farthest from the axis of rotation, or the extremities of the horizontal diameter of the ring, would move in the same manner as the ends of the cylinder. We should also expect that the ends of the horizontal diameter would always be attracted towards the nearest portions of the wire by means of which the electrical oscillations are being propagated ; and that these actions would be most marked at the antinodes of the vibrations, and would disappear in the neighbourhood of the nodes. As a matter of fact, if the ring is actually suspended at the nodes $b\,b'$, as indicated in Fig. 3, the phenomena observed are quite different. In the first place, the ring does not remain at rest under the influence of the oscillations, but is acted upon by forces of the same order of magnitude as those evidenced by the action of the cylinder when placed at the antinode of the vibrations. Moreover, the direction of the deflection shows that the force between neighbouring parts of the ring and cylinder is not an attraction, but a repulsion.

The repulsion is due to the oscillations, and its magnitude must depend on resonance, according to the same law as the electrical actions. The ring always sets itself perpendicular to the plane of

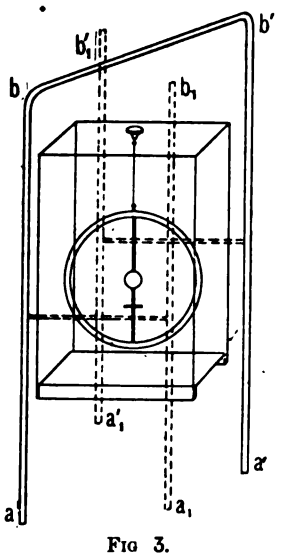


Fig 3.

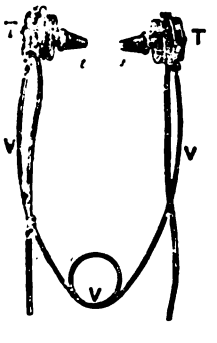
the wire, whatever its position with reference to it, provided it lies within the contour $b\,b'$. We can deduce, therefore, from these experiments alone that, in addition to the electrical vibration, there exists a vibration of another kind whose nodes coincide with the antinodes of the former, and that the directions of the two classes of vibration are perpendicular to each other. Referring to the experiments, we can easily recognise the new vibration as magnetic. The rapidly oscillating magnetic force must, by induction, produce a synchronous alternate current in the closed metallic ring, and the reaction of this current produces a deflection. The magnetic force is a maximum at the nodes of the electric vibration, and at these points its direction is normal to the plane of the wire, That the action between neighbouring portions of the ring and wire is a repulsion is easy to account for. The current induced in the ring is such as to neutralise within the ring the effect of the inducing current in the wire. The two currents accordingly flow in opposite directions and repel each other.

The other phenomena observed with the suspended ring can, without difficulty, be explained by the theory just given, although complications are sometimes introduced. Thus, for instance, with the arrangement indicated in Fig. 3, if the ring is moved away from the node b towards the antinode of the vibration, the repulsion diminishes very quickly, becomes nothing in a certain position, and then becomes an attraction increasing in amount until the antinode is reached. In a particular case the repulsion deflection at $b\,b'$ was 20 divisions, it disappeared altogether at about 95 centimetres distance from the ends, and became an attraction, the maximum value of which was measured by 44 divisions. In order to explain these results it is necessary to consider the simultaneous action of the electric and magnetic forces, the former being greatest at c, and the latter at $b\,b'$. We can verify this explanation by investigating the variation of the magnetic force after having eliminated the action of the electric forces. With this view place parallel to the wires $a\,b$, $a'\,b'$, two other wires of about 20 centimetres length, arranging the four wires symmetrically with regard to the equilibrium position of the ring, as indicated by the dotted lines in Fig. 3. Also join $a\,b$ to $a_1\,b_1$ and $a'\,b'$ to $a_1'\,b_1'$. In this way the electric action is evidently almost annulled, while the magnetic action is very little altered. We now observe a repulsion of the movable ring for all distances, diminishing to a minimum at the antinode of the electric vibrations. The minimum value is found to be four divisions. If the electric vibration were sinusoidal, the magnetic force would have disappeared at the node. The distribution of the electric force has already shown us that this hypothesis is not exactly correct, and we can thus understand the existence of magnetic force even at the antinode. The mechanical actions of the electric and magnetic forces, as theory indicates, are in general of the same order of magnitude. The predominance of one or the other depends essentially on the mutual actions of the nearest parts of the ring and the solid conductor. The more nearly these are like infinitely short wires, the greater is the relative importance of the magnetic force ; while the greater the surface of the conductors, the more the electric force predominates. From the above experiments on conductors of very simple form, it is evident that a conductor of any form, when placed in the path of a train of electro-magnetic waves, is subjected to forces of a very complex character.

ON A SMALL AND LIGHT TELEPHONIC RECEIVER, KNOWN AS THE BI-TELEPHONE.*

BY E. MERCADIER.

As a result of my experiments on telephonic effects, especially those of which particulars were given recently (*The Electrician*, Jan. 23, Feb. 20, 1891), I have been led to the following conclusions:—In a telephone which acts as a receiver it is possible to obtain, simultaneously, clearness in the reproduction of the various inflexions



of articulate speech and the loudness necessary for all the requirements of the telephone. For this purpose it is only necessary that the diaphragm should be thick enough to absorb most of the lines of force in the field of the magnet, and secondly to decrease the diameter until the fundamental note and the harmonics of the diaphragm are more shrill than those of the human voice, that is than the fifth octave of C.

It will be found that, in complying with these two conditions, we can get, with telephones having a very weak magnetic field, results which compare well in loudness, and which are more distinct than with instruments having a stronger field, and consequently more weight and of much larger dimensions.

It will be, on the one hand, readily understood that we can take small magnets divided into two branches, or even one only, like those of the early Bell telephones, with coils correspondingly small, thus reducing the weight of this portion to one-fourth of what it originally was, and also reduce, as I have shown above, the thickness and more especially the diameter of the diaphragm, resulting in a diminution in the size of the case in which it is fixed, and, secondly, the thickness of the diaphragm, and rendering it possible to replace the metal cases by ebonite, rendering the instrument still less weighty.

Having found it necessary in certain electrical researches to make use of telephones which would serve as very sensitive electroscopes, it occurred to me to use the foregoing results to construct a very light telephone, which could rest in the ears all day long and leave the hands entirely free.

I have designed several instruments of this kind, using telephones with either one or two poles joined by a spring of steel

* *Comptes Rendus*, 22nd June, 1891.

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wire, V, 2mm. in diameter, as shown in the figure, and to this I have given the name "bi-telephone." The case is of ebonite, the lid terminating in gutta-percha tubes, *t t*, which can be withdrawn and changed at will (each operator having his own tubes for his own personal use). The tubes enter the ear and press lightly on the aural canal, kept in place by a twist previously given to the spring. The spring passes under the chin of the operator, and the pressure may be regulated by pulling the two branches of V more or less apart. As these instruments only weigh 50 grammes (1·76 ounces) as compared with an ordinary telephone, which weighs about 400 grammes (14 ounces), and do not exceed 3 to 4cm. (1·17 to 1·56in.) in diameter they produce neither fatigue nor even inconvenience after several minutes' use.

The steel spring may serve to connect electrically two of the four ends of the coils, so that two wires will be sufficient to connect the telephones with the instrument with which they are being used. This spring may also be strongly magnetised, and help to strengthen or maintain the magnetism of the telephonic magnets, thus serving three purposes—mechanical, electrical and magnetic.

Bi telephones thus designed for scientific purposes have been tried as receivers with ordinary microphone transmitters on telephonic lines; for instance, underground lines, 50 to 75km. (31 to 46 miles) in length, on a line 800km. (500 miles) long, and on the new London-Paris line. They have given good results, and have been adopted for use in connection with apparatus authorised by the Government for telephonic work.

These instruments are suited to all kinds of telephonic transmitters at present in use, and may be used by persons who have to take notes while transmitting or receiving messages or even writing them out entirely.

ON THE ELECTROMOTIVE FORCES OF GALVANIC ELEMENTS.*

BY A. OBERBECK AND J. EDLER.

As amalgams in which the percentage is pretty low behave, so far as electromotive force is concerned, almost exactly as the metals themselves, an element consisting of the combination: mercury | electrolyte | amalgam was chosen, and the E.M.F. determined by the compensation method with the aid of a mirror galvanometer. The tests included the metals zinc, cadmium, tin, lead, and bismuth, in a large number of solutions of sulphates and chlorides of various degrees of concentration. In the result it appeared that the electromotive force depends principally on (*a*) the metal forming the electrodes; (*b*) on the electro negative constituent of the solution.

The order of the metals in the solutions always remains the same, although their positions approach and recede from one another. The same is also true for free acids. The electromotive forces are greatest (and nearly equal) for sulphuric and nitric acids. For hydrochloric acid they are much smaller and nearly equal to those obtained with a neutral chloride. For solutions of salts the values of the E.M.F.'s follow the order: sulphate, nitrate, carbonate, chloride, bromide, and iodide. The electromotive forces only depend upon the metal of the salt in solution, when this metal is the same as that of the electrode. In this case the E.M.F. is smaller. If these results are compared with those published by J. Thomsen on the heat equivalents of the above metals (except bismuth), a distinct correspondence between the differences of these equivalents and the observed electromotive forces will be noticed.

The authors arrive at the following conclusions:—

1. The E.M.F. is to be calculated from the heat equivalent of the chemical process, taking into consideration the local evolution of heat that takes place at the electrodes.

2. Want of constancy in elements is due to the taking up of molecular layers of a dilute solution of the metal of the electrode. The degree of concentration depends upon many circumstances, which must be the subject of future experiments.

* *Wied. Ann.*, Vol. XLII., Part 2.

Mica.—The recent reported discovery of a great mica mine about 1,300 miles north of Adelaide seems to have been somewhat exaggerated. Mr. H. Y. Lyell Brown, the Government geologist, went to see the mica, and was surprised to find only a long pit, about 6ft. in depth and about 60ft. in length, from which nearly all the mica had been taken. There was no appearance of any continuance of the deposit. Only about three tons of mica in all have been dispatched from the mine.

A PORTABLE FORM OF CAPILLARY ELECTROMETER.*

BY A. BERGET.

This instrument does not possess any essential novelty. The marvellous apparatus of Mr. Lippmann was, in fact, complete when it first appeared, and its author has left no room for further development. The model which I have made only differs from the original in the arrangement of its parts, the object of the new design being to render the instrument transportable. The delicate part of a capillary electrometer is the glass point, and the chamber into which it dips. I have combined these two parts into a single piece, represented full size in Fig. 1. The following is the description of this portion of the instrument.

Fig. 1.

The glass chamber, A, terminates below in a bulb, M, containing mercury, which can be brought to any given potential by means of a platinum wire, *m*, fused into the glass of the tube. Its upper portion is fused into a tube, M', of the same diameter, full of mercury, and terminating in a capillary point *p*. A second platinum wire, *m'*, renders electrical connection possible with the mercury inside the upper reservoir. A very small hole, *o*, pierced in the glass tube A, near the point of fusion with the upper tube, is useful for the introduction of the mercury and the acidulated water, while, at the same time, it ensures that the liquid is under atmospheric pressure.

The entire apparatus is represented in Fig. 2. The capillary point and the reservoir are seen at E, on the plate of the microscope, M, used for observing the indications. In order to apply pressure to the mercury, M', so as to make it penetrate the point *p*, two glass reservoirs, R and R', united by a caoutchouc tube, C, are employed. These reservoirs are supported at different heights from a metal upright, *c*, *c'*, *c''*. The pressure at R is measured, in mercury units, by the difference of level of R and R'. This pressure is transmitted by air compression through the caoutchouc tube, H, to the mercury, M', of the electrometer. The reservoir, R', is fixed, while the level of R is adjusted by hand until the meniscus appears in the capillary tube and near the end.

The terminals, P, are clamped by a screw, V, to the lid of the box, B, into which the whole apparatus can be packed, and which also serves the purpose of a support. The metal column, *c*, *c'*, *c''*, divides into four parts, each about a quarter

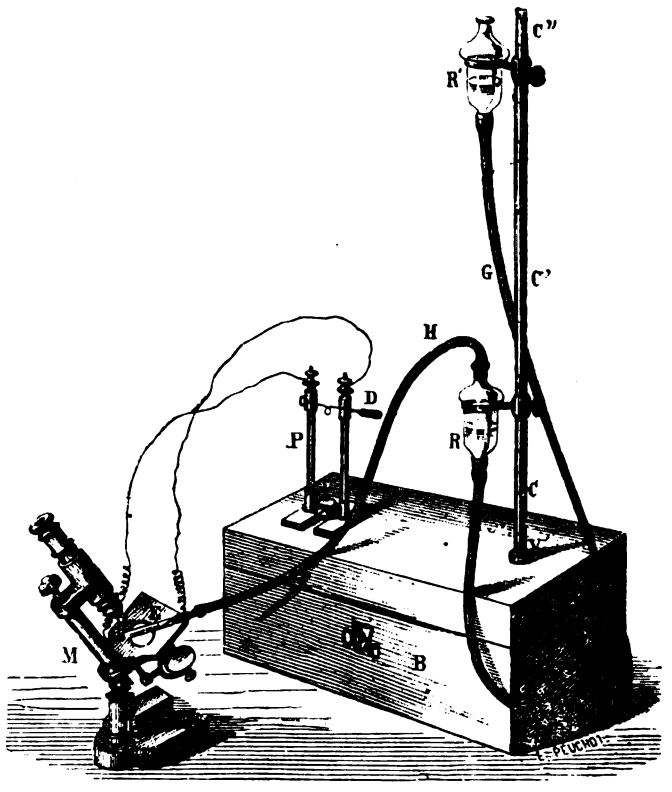

Fig. 2.

of a metre long. The microscope, M, specially constructed by Mr. Nachet, magnifies 300 times. The other parts of the instrument have been very skilfully constructed by Mr. Victor Chaubaud.

* Translated from the *Journal de Physique*, for May, 1891.

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THE PROGRESS OF ELECTRICITY.*

I have the pleasure this morning of bringing before you the subject of the relative merit and cost of gas and electricity for lighting purposes. I propose to consider the subject solely from a practical point of view, and to deal rather with the financial aspects of the question than the mere technics. Of course, I shall have to deal a good deal with figures, and figures are proverbially dry. It has been said that you cannot extract a joke out of figures, and that you can always manipulate figures to suit your own particular view. Neither statement is quite true, because we have all of us heard the old story about the two men contesting with each other, and one man saying, "Why, sir, it is as plain as 2 and 2 make 4;" and the other man saying, "But 2 and 2 do not make 4, 2 and 2 make 22." And, again, as to manipulating figures to suit one's own purpose, I daresay it will be said I am going to do very much that kind of thing myself. But I am addressing you—if I have any prejudice at all—I am addressing you as a gas shareholder, and not as an enthusiastic electrician. Comparisons of costs are generally fallacious, because the comparison depends so very much upon the point of view taken. The questions we have to decide are principally such as these: What is the capital involved in any particular industry, what the profit derived, and what has the consumer to pay? I am not going to bring before you any fanciful figures. They are published figures, they are figures you can get for yourselves, and you will be able to check the deductions I am going to make. Now, I have taken the case of Manchester for the simple reason that I have more authentic records of what is done in Manchester than I have of what is done in any other town. And from the records of the gas department in Manchester, it seems that one ton of coal in Manchester produces 9,611 cubic feet of 20 c.p. gas. I take Manchester, also, because it is above the average —20 c.p. gas is rather in excess of the average of the country, which is not more than 15. Well, since this is the quantity of gas produced by a ton of coal, it follows that 1lb. of coal will produce 4·29 cubic feet of gas; and if 4·29 cubic feet of gas is burnt per hour we get in Manchester an illumination of 17·2 candles. Now, in drawing a comparison between gas and electricity I must use one technical term which is now coming into general use, and will have to be understood by every engineer, whether electrical or municipal, that is, the term watt. A watt is the mechanical unit of power which is exerted by a current, one ampere flowing through one ohm for one second. It enables us exactly to tell you how many lamps will be lighted and what light they will give. So, in the use of electrical energy, if we burn in a steam boiler 7lb. of coal, we shall 1·3 H.P. of electrical energy, but represented in watts we shall 1,000 watts, and a 1,000 watts is called a kilowatt, so 7lb. of coal will give us kilowatt-power of energy, and I will show you what light it will give. In the same way as I have shown that 1lb. of coal distilled into gas will produce 4·29 cubic feet, or 17·2 candles of light, so 1lb. of coal burnt in a boiler to produce steam will give us electrical energy that will give—I will show it in two forms, one the arc lamp, the other the glow lamp, which we use in our houses, 1lb. of coal burnt per hour, and used in electrical energy, if burnt in the form of a glow lamp, will give 48 candles, and if burnt in the form of an arc will give 288 candles. So there we start with the first theoretical fact that I bring before you, that 1lb. of coal distilled into gas in Manchester gives us a candle-power of 17·2; 1lb. of coal, if converted into electrical energy in the form of a glow lamp, 48 candles, and in the form of an arc 288 candles. That is theoretical. We will now come to hard facts.

In Manchester, during the twelve months ending March 30, 1890, the income derived from gas was £434,351, the expenditure was £360,804, showing that in Manchester a balance of £73,549 was derived from gas. That balance was devoted to meeting interest on loans, depreciation of plant, and the cost of public lighting. But from that fact I derive this: that the cost per 1,000 cubic feet of gas to the Corporation of Manchester was 2s., therefore it costs the Corporation of Manchester 2s. to produce 4,000 candles of light. Well, now, I am obliged to use an estimate for the simple reason that at present the Corporation of Manchester have not established a central electric lighting station. They have obtained a Provisional Order so as to enable them to do this, and they are now considering whether they shall carry it out themselves, or transfer their power to another body. In making an estimate of the cost of electricity in Manchester, we have to take the experience of the cost of manufacturing electricity elsewhere, and on this point there is, perhaps, more reliable, accurate, and truthful facts than with, perhaps, anything else connected with electricity. The Board of Trade exercise such a powerful control over the electric lighting interest that there is no hankey pankeying with the accounts. The accounts of expenditure must show the cost of production, and these are within the reach of everyone.

* A Lecture by W. H. Preece, F.R.S., before the Incorporated Association of Municipal and County Engineers, at the Institution of Civil Engineers, on Friday, 26th ult

My own experience of electricity is a pretty extensive one. We have a great many of our post offices lighted with the electric light, and I have a central station at the General Post Office, to see what we are doing; we have a very large plant, and we are going to produce in St. Martin's-le-Grand sufficient power to light 10,000 lamps, and we are laying down another plant at Coldbath Fields, where we shall generate electricity for another 10,000 lamps. From my own experience, I can say that we can produce a kilowatt or Board of Trade unit for 4d. It means that we can produce 4,000 candles by gas for 2s., we can produce 4,000 candles by the arc lamp for 8d., and we can produce 4,000 candles by a glow lamp for 4s. So you see on these facts—I am not calling them estimates, for they are ascertained facts—on these facts the theoretical estimate of light produced is twice as much by the glow lamp as by the gas lamp. These are theoretical estimates, they are not practical ones. However proud we, as gas engineers, may be of producing gas of 20 c.p., when you come to the houses and shops of users and consumers you find this 20 c.p. is very considerably diminished. This is a very important question, and one which some six or seven years ago concerned us in the Post Office very much, and Mr. Vernon Harcourt, F.R.S., and I devoted considerable time to experiments on this question. Mr. Vernon Harcourt, who is a very painstaking, careful, and accurate experimenter, found taking the ordinary burner, supposed to be consuming 5ft. per hour and giving 15 c.p., really gives only 10 candles, due partly to dirt in the burner, but due principally to the flickering of the light of the gas caused by draughts of air into the room. So, while a light burning in a special burner in a laboratory may give 15 c.p., when you come to a room or passage that lamp will only give 10 candles. This *pro ratâ* value is equally true of Manchester as of elsewhere. The result is you must add 30 per cent. to the cost of the gas for your 4,000 candles. There is another point. I ought also to say this depreciation in the value of light is not only true in the case of gas, but it is also true to a certain extent in the case of electricity. The lamps when they are still fresh and new will give 16 c.p. light, but after they have been used 200 or 300 hours the electricity flowing through the carbon filament that causes the carbon to evaporate, it flies away in straight lines, and is deposited on the glass bulb, obstructing a certain amount of light. Again, you have a certain amount of dirt and dust collected on the outside; the consequence is you have a depreciation in the amount of your electric light, though not quite so much as in the case of gas. I ought to mention, when drawing any distinction between the light-giving, whether electricity or gas, in the light given by each, that 5 cubic feet of gas will give, practically, 10 c.p., and 33 watts, in its normal power, will give you also 10 c.p. There is one element in gas that is a very serious loss indeed. That is the tremendous waste of gas that occurs through lights being left burning unnecessarily. Persons who have their houses and offices lighted with gas know that servants, as a rule, go and light all the burners, unless a careful householder goes round and cuts off those that are not wanted. The result is this: from this very element of waste there is 20 per cent. of gas used more than is necessary. It is brought out by this. Taking the nine principal towns in this country, and taking the average number of hours of gas and electricity burnt in this country, the average number of hours for gas is 600, the average number of hours for electricity is 460. This is taken from the average of 200,000 electric lamps which are now alight in London; while in gas you have a tremendous waste from these burners being left flaring, you have no waste from electricity. Electricity is so easily lighted, a tap turns it on and off, that there is a species of instinct that teaches everyone, that you only want your electricity lighted in the place where you require, and the result is you get no waste. The result of it all comes to this, that the comparison between gas and the glow lamp is not 2s., as against 4s., which is theoretical, but the practical figure of 3s. 8d. We can prove this. The average amount, taking the returns from the chief nine towns of this country, paid per gas burner per annum, is 9s., while the average price of gas is 3s. per thousand feet; the average price of the 200,000 electric lamps burning in London is 10s. So we have these two facts, that the average price paid by the consumers for gas is 9s. per annum, the average price paid by the consumer to the electric light provider is 10s. This is rather a startling figure, because most people are under the impression that the cost of the electric lamp is very much greater than gas, and I have been myself very much surprised to find that the price I pay in my own house, where I generate my own electricity, and have done so for the last eight years, was so very small. I find, although I have a gas engine and accumulators, and have over 70 lamps in my house, I am not paying more than when I used gas. I have taken all the companies in London, and have tabulated the revenue derived by each company per lamp per annum, for a 33 watt light and a 10 candle burner, and I find that the Metropolitan Electric Supply Company derive a revenue of 12s. per lamp, the Chelsea Electric Supply Company 8s. 6d. per lamp, the Kensington and Knightsbridge Company 9s. 2d. per lamp, the House-to-House Electric Supply Com

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pany 11s. 6d. per lamp, St. James's and Pall Mall Electric Supply 9s. 6d. per lamp, and a company in Brighton charges 8s. 6d. per lamp; the mean being, for 200,000 lamps, 10s., which compares with 9s. for gas. Well, I have also verified this ratio between the two lights, and in the General Post Office, where we burn a great quantity, and where night operations are extended to late hours, and we begin at early hours, there, from the experience of two years' working and comparison, we find that gas costs 18s. per lamp per annum, and electricity 22s., the ratio being 9s. and 11s., and not 9s. and 10s. as with the companies. Take the case of Manchester, where gas is cheaper than in London. The average price paid per lamp for gas in Manchester is 7s. 6d. per annum. Well, taking the cost of electricity at 4d. per unit, the revenue that Manchester will derive from public lamps will be 8s. 4d. per annum, against 7s. 6d. for gas. Of course, the rates of charges vary very much in London; the private companies are charging 7d., in other instances 8d. per unit. In Bradford they commenced by charging 5d., and have since raised it to 6d. In Newcastle they are charging 4½d. to the public, and they are allowing large discounts on that, 4½d. to the large users of electricity. We in the Post Office are large users, and we have a discount of 20 per cent. off that 4½d., which makes the cost of our electric lighting in Newcastle very nearly approaching that of gas. In factories where they have isolated installations, all the facts show that electricity is cheaper than gas. I have figures from Bolton, from Messrs. Horrocks, Crewdson, and Co., who are amongst the largest employers of labour in that district. They have had the electric light going for six years, and while they were using gas the cost per lamp per annum came to 5s. 6¾d. Since they have generated their own electricity it comes out that their lamps cost them 4s. 4d. per annum, so there is a considerable reduction. Those who know Manchester know that under the Exchange there is a large restaurant, which used to be unbearably hot when lighted with gas. The manager, two years ago, replaced gas by electricity, and finds he has not only saved £800 a year in the cost of the light, but has probably doubled his income by allowing his guests to have their meals in comfort. So far as figures go, I have given you hard facts to show there is not much difference between electricity and gas. I tell all my friends that my house is lighted by gas; but I burn my gas in the garden, and allow all the vitiated gases to disappear in the air, while I extract from the gas what I want—light—and have it in my house. If you take 25 cubic feet of gas and burn it direct, you will only get 50 candles of light. If you burn your 25 cubic feet of gas in a gas engine, and produce electrical energy, it will give you 160 c.p. of light in the house. So, with a little care, you are able to still use the gas and treble the amount of light in the house.

I see in the programme you are going to the Royal Naval Exhibition. The Royal Naval Exhibition is lighted by electricity. There is an engine-room there fitted up with probably the latest developments of electrical machinery. Electrical machinery is constantly changing. We are daily producing improvements of some kind or the other. The electrical room there is well worth your visit, and you will see there how the electrical energy is generated, and will probably find that one dynamo and one engine is supplying light to the whole of the Exhibition. On Saturday you are going to have a still more interesting visit to the works of the Electric Supply Corporation, at Deptford. They are not complete, but there you will see preparations that are being made for lighting one million lamps in London. At the present moment they have only sufficient machinery to allow of 200,000 lamps going. You will find there the space required for electrical machinery to light a million lamps. One of the great merits of electrical machinery over gas machinery is the small space which it uses. Gas requires 100ft. by 50ft. for every million cubic feet made per annum; with electricity 100ft. by 50ft. is quite sufficient to light up one of our big towns. We must not neglect other points. We must not neglect the fact that when we deal with electric lighting we are removing from our midst a source of deterioration to our goods, chattels, and fixtures. Another point is, that it adds so much to the security of our buildings. It is not absolutely safe; it would be absurd to say it was. Carelessness and folly will cause fire by electric current as by gas. It requires supervision and the usual care which engineers know so well how to exercise. But it is this question of health which I want to thrust down everybody's throat as the great merit of electric lighting, if the price was very great indeed. We find in the Savings Bank Department of the General Post Office the cost of the electric light is paid for by the increased work we get out of our staff. The introduction of the electric light has diminished the hours of absence two hours per day per annum. That put down at 10d. per hour, which is the ordinary overtime rate in Government service, means we save £680 a year. Our electric light costs us £700, so it is really only costing us £20 a year. So in the General Post Office we succeeded in putting in the electric light just before Christmas, and the Chief Controller told me the electric light enabled them to get out their work quicker than ever before, and it was equal to 200 men. The purity of the air you breathe, the sanitary aspect of the electric light, is the point and aspect which commends it so much to municipal engineers and local authorities. We must not forget that when gas is let into the air the impurities in it are poisonous. Gas burned in a bedchamber is as injurous as bad water and bad smells. The chief duties of the Municipal Engineer have been to improve the sanitation of our towns, and to remove vegetable and decaying matter from our water supplies. But the duties of the Municipal Engineer will not be complete until he takes in hand the electric light. There is one other point I want to urge upon you, that is, that it is not the lamp of luxury. The common argument is that it is the lamp of luxury, that it is only the rich man who can afford to pay for it. The electric light is the poor man's light. If you can get the light for 8s. 4d. per lamp per annum, it is to the benefit of the working man, who has to live in small, ill-ventilated rooms, to have the light in his home. Now, the price of gas is going up; the price of electricity is coming down. The price of gas is going up from labour disputes and strikes; the price of electricity is coming down, because we know so very much more about it. We can produce 1,000 feet of gas for 1s. 10d., the extra 2d. is for management and collection, though I have no doubt that gas engineers will claim to be able to produce it for 1s. 7d., or 1s. 4d., or 1s. per thousand feet.

What can we produce electricity for? I have just been making a most exhaustive inquiry into the cost of electricity in the production of phosphorus and copper. They are two industries where the use of the current is continuous. You have your engines, dynamos, and everything working at its maximum efficiency. In electric lighting the load is irregular. People will not go to bed at the same hour, or rise at the same hour, so your load-line is variable. Where your load-line is constant, as in the production of copper and phosphorus, you can produce your electricity for one-third of a penny per unit. There is no mistake about that figure. The cost of production of a unit of electricity with a constant load is but one-third of a penny. What does that mean? If we take the theoretical difference between gas and electricity, it is equivalent to gas produced at 3d. per thousand feet. When we have the prospect of producing electricity at one-third of a penny, equivalent to gas at 3d. per 1,000 feet, it shows what a vast field of development is before the electric light. There is one reason why gas is still ahead of electricity; it is that there is such a market in this country for residuals. The price obtained for coke and ammoniacal liquors, and the other ingredients of gas works, practically reduces the price of coal in London to the gas manufacturers to 4s. 6d. per ton. We have to pay in London for Welsh coal 23s. per ton; that is why we have to pay more for the electric light than for gas. When we come to places like Gibraltar and Malta, where I went to see whether it was possible to use the electric light instead of gas, where there is no market for residuals, it required no difficulty on my part to say that it was possible to produce electricity cheaper than gas. I have endeavoured, to the best of my ability, to bring this matter before you as practical men, and I want you, if you agree with my conclusions, to point out to your different Boards that the duty of a Corporation is to look into this matter, not only from a financial but from a political as well as a sanitary, but, above all, from a philanthropic, point of view, and endeavour to persuade, as I have endeavoured to persuade you, that the electric light is not the light of luxury, but the poor man's lamp.

PHYSICAL SOCIETY.

At the meeting of the Physical Society, on Friday last, Prof. W. E. AYRTON, F.R.S., President, in the chair, the following communications were made:—

"The Construction of Non-Inductive Resistances."

BY PROF. W. E. AYRTON, F.R.S., AND MR. T. MATHER.

In making some transformer tests, about three years ago, the authors had occasion to consider the construction of electric conductors, the impedances of which should be practically equal to their resistances. This condition could only be fulfilled by making the inductance small in comparison with the resistance, and as the former does not depend on the material employed (excepting iron) it was important to use substances of high specific resistance. Carbon or platinoid being available, the latter was chosen on account of its low temperature coefficient. One form of resistance exhibited consisted of strips of thin sheet platinoid, about 6 metres long and 4 centimetres wide. Each was bent at the middle and doubled back on itself, thin silk being placed between the contiguous parts, and narrow ribbon used to bind the parts together. Twelve such strips arranged in series had a resistance of 2·95 ohms, and would carry a current of 15 amperes without changing its resistance more than $\frac{1}{10}$ per cent. This strip resistance was made by Messrs. C. A. Lamb and E. W. Smith, who, at that time (1888) were students in

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the Central Institution, and to whom the author's best thanks are due for the praiseworthy manner in which they surmounted the difficulties which presented themselves. Another form of resistance, designed for portability, consisted of bare-wire spirals, each length having a left-handed spiral placed within a right-handed one of slightly larger diameter, and the two being connected in parallel. This device was found to reduce the inductance to $\frac{1}{10}$ or $\frac{1}{20}$ of that of a single spiral, accordiag as the diameters of the spirals approach towards equality. When the spirals are made of platinoid wire the ratio of inductance to resistance is very small, averaging about $\frac{1}{500000}$.

On "Pocket Electrometers,"

BY C. V. BOYS, F.R.S.

This communication described modifications of electrometers adapted for portability. As quartz fibres increase the delicacy and diminish the disturbing influences affecting instruments, much smaller controlling forces can be employed than when silk is used for suspensions. He had, he said, pointed out some time ago the great advantages arising from making galvanometers small. Applying similar reasoning to electrometers, he remarked that making an instrument one-tenth the size of an existing one reduced the moment of inertia of the needle to $\frac{1}{100}$, whilst the deflecting couple for given potentials would only be $\frac{1}{10}$ of its former value. The small instrument would, for the same periodic time, be 10,000 times more sensitive than the large one, provided the disturbing influences could be reduced in the same proportion. This, however, was not ordinarily possible, for any method of making contact with the needle such as by a fine wire dipping into acid or mercury prevented very small controlling forces being used. Still, by suitable devices, a large proportion of the full advantage could be obtained. A freely suspended needle without liquid contacts was essential to success. The first instrument described was one in which the needle was cylindrical (Fig. 1), contiguous quarters being insulated and connected to the opposite ends of a minute

FIG. 1.—Cylindrical "needle," with four insulated sections containing a dry pile.

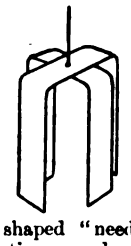

FIG. 2.—Cross shaped "needle," consisting of a strip of platinum and a strip of zinc, charged by its own contact difference.

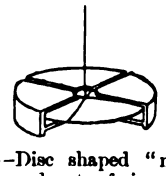

FIG. 3.—Disc shaped "needle," with alternate quadrants of zinc and platinum, one of the enclosing quadrants being removed.

dry pile placed within the needle; opposite quarters were then at the same potential, and at a different potential to the other pair of quarter cylinders. This was suspended within a glass tube silvered on the inside and divided into four parts by fine longitudinal lines. In such an instrument the needle and quadrants are reciprocal, and the deflection depends on the product of the difference of potential between the quadrants and that between the parts of the needle. Owing to the dry pile not being constant, the instrument was found unreliable, but when working at its best, a Grove cell would give 30 or 40 millimetres deflection. The next step was to make a cross shaped needle of zinc and platinum (Fig. 2), and rely on contact electricity to keep the parts of the needle at different potentials. This bold experiment proved remarkably successful, for the instrument was very sensitive. A disc-shaped needle, with quadrants alternately zinc and platinum, was then employed, and by this a small fraction of a volt could be measured. The weight of the disc was only $\frac{1}{20}$ of a gramme, and the instrument could be turned upside down or carried about in the pocket with impunity. Another small instrument with the quadrants of zinc and copper (Fig. 3) was exhibited, and by rotating them through an angle of 90deg., so as to bring them in a different position relative to the parts of the needle, a deflection of several degrees of arc was produced. In the course of his remarks, Mr. Boys made several suggestions relating to ballistic electrometers and electrostatic Siemens dynamometers, and pointed out the possibility of instruments such as he had exhibited being of use in elucidating the obscure points in connection with so-called "contact electricity."

The PRESIDENT complimented Mr. Boys on the beautifully simple and remarkably sensitive electrometers exhibited. He remembered that some years ago Mr. Gordon made a very small electrometer, but its insulation was insufficient for electrostatic work. He agreed with Mr. Boys as to the advantages of small instruments, providing sparking across or tilting of the needle could be prevented. On the other hand, he thought the use of small potential differences on the needle was a step in the wrong direction when great sensibility was required.

Prof. PERRY asked if the needle could not be kept charged by occasional contacts with a charged acid cup.

Mr. BOYS said he had originally intended using a fairly highly-charged needle, but had not yet done so. He also suggested that an electrometer of very small capacity might be made by reducing the quadrants surrounding a disc needle until they became like small tuning forks.

A Paper on "Electrification due to the Contact of Gases with Liquids," by Mr. J. Enright, B.Sc., and one on "The Expansion of Chlorine by Heat," by Dr. Arthur Richardson, was taken as read.

The following correction should be made in the report of the meeting on June 12th. For the first sentence in Mr. Blakesley's remarks on Dr. Lodge's experiments substitute:—"Mr. Blakesley asked whether the pitch of the resonant jars altered when the distance between the circuits was varied, for, according to theory, the mutual induction should diminish the self-induction, and cause the oscillations to be more rapid."

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *June* 20, 1891.

More Litigation.—The past week has been a rather quiet one in electrical circles, except for wars and rumours of wars over infringing patents. In addition to the Edison lamp litigation, Brush storage battery suit, and the instituting of legal proceedings against the West End Railway Company for infringing the Sprague patents, two more new legal complications present themselves. Mr. J. C. Henry, one of the pioneers of electric traction in this country, has begun proceedings in the United States Court at Kansas City, Mo., against the Interstate Rapid Transit Company, using the Thomson-Houston system. This suit is brought under Henry's patent of a very early date. The points at issue relate to a cross-suspension or span wire system of holding the trolley wire, the under-running trolley, the arrangement of circuits in double multiple, insulated feeders, methods of curve construction, and form of trolley insulators. Besides Mr. Henry's suits, the Adams Electric Railway Company, of St. Louis, has begun proceedings under the old patent that showed an electric motor placed in the car-wheel and directly upon the axles. It seems probable, therefore, that the electric railway field is likely to be the arena of some lively litigation. It may be added that the Thomson-Houston Company and the Edison Company are also likely to be very soon involved in proceedings on the carbon brush patent, once owned by the Westinghouse Company, and sold, with the reservation of a licence.

The Electric Club.—The New York Electric Club was the scene of a very pleasant smoking concert last evening. One hundred and fifty members were present at the club-house, and the evening was a very enjoyable one, enlivened by music, recitations, interesting phonograph performances, and the like. The Electric Club is rapidly getting to be a central rendezvous for the best known electricians in the city, and their informal entertainments are widely appreciated.

Agitation Against the Trolley System.—The agitation over the introduction of the trolley system into Brooklyn still continues, and no decision has yet been reached. Somebody is very hard at work in spending a good deal of money in arousing popular indignation against the trolley. The outcome will very likely be a limited extension of the present trolley system on the outskirts of the city, but there is scarcely any doubt of the temporary success of the obstructive party.

Long Distance Telephone Lines.—A recent Paper by Mr. Gisborn, before the Royal Society of Canada, has again stirred up the question concerning the use of long distance telephone

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lines. It has been an open secret for a good while that the wires of the long-distance companies have sometimes been used for purposes other than telephonic, and in Mr. Gisborn's description of rapid automatic transmitter work is a very broad hint as to what lines were used in the experiments, and it would be an interesting question to determine how far these experiments have run into commercial work. It has been rumoured more than once that the Western Union is likely to bring suit under the contract that prohibits tne use of telephone lines for telegraphic work. A few trunk lines with automatic transmitters would be a pretty formidable factor in the transmission of messages between large centres of population, and we may be treated to an interesting revelation as to what can be, and, perhaps, has been done. The Western Union Telegraph Company is not at all likely to sit quietly in the presence of an active competitor, and, on the other hand, the telephone companies, in view of the approaching expiration of the patents, would not be at all averse to having an extensive and lucrative business to fall back upon.

CORRESPONDENCE.

THE CHEMISTRY OF THE SECONDARY CELL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of the 26th June I am glad to see Mr. Hibbert has called attention to a passage in my article on the Chemistry of the Secondary Cell which might mislead those unacquainted with the work of Dr. Gladstone and himself. I had no intention of implying that the analytical method was employed both in the course of the work on litharge and minium, but meant that reviewing their work on the formation of an oxysulphate in the cell as a whole the non-formation was not absolutely proved, because it was just possible the method employed in part of their work might have destroyed the oxysulphate.

As analysis was not made use of in the work on litharge it did not occur to me that my remark could be taken as applying to that Paper; however, I am much obliged to Mr. Hibbert for explaining a passage which is ambiguous.

Hoping you will be able to find space for the above explanation.—Yours, &c., G. H. ROBERTSON.

30, Hemstall-road, West Hampstead, N.W.,
June 27, 1891.

MAGNETIC SEPARATOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I notice in your commentary on the electrical apparatus at the Royal Agricultural Show, that you do not notice the magnetic separator shown by the Hardy Patent Pick Company, of Sheffield, and made under the patents of Mr. Elliot, myself, and Mr. C. W. Atkinson, and manufactured by Messrs. W. T. Goolden and Co. This is the more curious as the separator was by no means a small machine, being nearly 5ft. in diameter, and weighing probably, with the timber work on which it was mounted, over a ton.

As this is the first time this machine has been publicly exhibited, and as we believe it is an important improvement on any magnetic separator previously used for this purpose, we should be glad if you would note this correction. I may also add that a magnetic separator of a different class was exhibited by Messrs. Harrison Carter and Co.—I am, Sir, &c.,

LLEWELLYN B. ATKINSON.

Woodfield Works, Harrow-road, London, W.,
June 29th, 1891.

THE CAUSTIC SODA AND CHLORINE SYNDICATE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Our attention has been called to an article in your issue of the 19th ult., on the Electrolytic Production of Caustic Soda and Chlorine. The article is a model of fair criticism, and we have no wish to minimise the force of the considerations advanced by the writer. We would ask, however, your permission to add the following few particulars in explanation of the "report" (prepared for submitting to a non-technical directorate), for which we are gently taken to task. The back E.M.F. of the ions separated under the conditions of the Greenwood cell is about 2·5 volts.; the current density under the conditions of our experiments was about 2 amperes per square decimetre of sectional area of diaphragm. From these data it is easy to estimate the factors of the aggregate fall of potential, amounting to from 4·5 to 5 volts between the terminals, and to see that the resistance introduced by the diaphragm is satisfactorily low.

The electrolysis being unattended by secondary reactions between the ions—as was shown by the absence of chlor-oxygen compounds in the solution of the cathode compartment—there would be no reason for any sensible divergence of the results obtainable in the large and small scale. Mr. Greenwood's claim for a 70 per cent. (ampere) efficiency we confirmed on the small scale, and are satisfied can be realised on the working scale.

The important points to be solved are as you indicate, the life of the anodes and of the diaphragms, that is the costs of maintenance. The recognition of this was the basis of our recommendation to try the system on the scale of a 40-H.P. installation.

We cannot trespass on your space, nor is the opportunity a favourable one, to enter upon a thorough technical discussion of the prospects of the application of current energy to this department of chemical production. The Hermite process, to which you have also alluded in your article, has made considerable headway in France, and we hope to have the opportunity of including an account of the results of running the several installations in the general survey which we intend to prepare for the technical public.—We are, Sir, &c.,

4, New Court, W.C., July 1, 1891. CROSS and BEVAN.

LEGAL INTELLIGENCE.

United Telephone Company v. Ladd and Co.

This was an action in which the plaintiff Company, of Oxford-court, Cannon-street, sought to recover against the defendants, 116, Queen Victoria-street, the sum of £20 and interest as the rental of a telephone used by them. Mr. Payne was counsel for the plaintiff Company, and Mr. D'Eyncourt appeared for the defendants. Mr. Payne said the agreement which was entered into by the defendants made them liable to pay the amount claimed. The defendants undertook to pay the amount in advance, and if they desired to put an end to the agreement, three months' notice had to be given, expiring on October 1st. No verbal notice could be recognised. In September last year the plaintiffs wrote to the defendants applying for the rent due, and in reply they received a letter saying they wished no longer to continue the use of the telephone. They refused to pay the rent, saying the telephone had been out of repair, and endeavoured to repudiate payment in that way. The defendants had set up a counter-claim for damages, but as it was out of time it could not be entertained. Mr. D'Eyncourt said the plaintiff Company agreed to keep the telephonic apparatus in working order. This had not been done, and the telephone was quite useless to the defendants during the latter part of the time for which the plaintiffs had been paid. They found it easier to send a messenger with a letter rather than use the telephone. They had paid since October, 1885, till last October, and during the last year it was continually becoming out of order. The defendants often tried to use it, but could not get attended to. On one occasion the bell kept ringing for a long time, and at other times the defendants were cut off in the middle of a conversation. Once, when the defendants tried to communicate with another subscriber, they heard a voice in the plaintiffs' office saying, "Oh, it's too late; tell them they are engaged."

The learned Commissioner said all of this was the subject of the counter-claim, and as the counter-claim was out of time, he must find for the plaintiffs on the claim, with costs.

BOOKS, &c., RECEIVED.

"An Introduction to the Mathematical Theory of Electricity and Magnetism." By W. T. A. Emtage, M.A. (Oxford: Clarendon Press.)

"A Manual of Practical Electro-Therapeutics." By Arthur Harries, M.D., and H. Newman Lawrence. (The Nursing Record Series, No. 3.) (London: Sampson Low, Marston and Co.)

"Vorlesungen über Maxwell's Theorie der Elektricität und des Zichtes." Part I. Von Dr. Ludwig Boltzmann. (Leipsig: J. A. Barth).

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TRADE NOTES AND NOTICES.

[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.]

NOW READY.—"THE ELECTRICIAN" PRIMERS (38 in all), in two volumes. Price per volume 2s. paper covers, 2s. 6d. cloth; post free, 2s. 2d. and 2s. 9d. respectively. Single copies, 3d.; post free, 3½d. Prospectus on application to the Publisher.

TELEPHONE PATENTS.—Our readers will find in our advertisement columns a notice from the Directors of the National Telephone Company (Limited) calling attention to the fact that it is only the first of Edison's transmitter patents which expires on the 30th inst., and warning the public against the manufacture, sale, or use of the various forms of carbon transmitters in common use in this country, the patents for which do not expire until the latter part of 1892 and the beginning of 1893.

MESSRS. GILBERT AND CO.—This firm have secured the contract for lighting Messrs. Hopkins' Market at Cardiff.

THE LEEDS ASSOCIATION OF ENGINEERS.—This association has more recently taken commodious rooms at 5, Park-lane, Leeds. Mr. J. A. Tempest is the honorary secretary.

MESSRS. WOODHOUSE AND RAWSON UNITED (LIMITED).—We are notified that Mr. Charles A. Smith, of the Athenæum, 71, Temple-row, Birmingham, has been appointed agent for Birmingham and district of the above firm. Mr. Smith has opened show rooms at the above address, where samples of Messrs. Woodhouse and Rawson's manufactures may be seen, and where local orders will be executed from stock.

THE WEYMERSCH BATTERY.—We have received from the Weymersch Battery Company some illustrated particulars announcing, among other matters relating to the battery, that it can be seen in action every day at the offices of the Company, where it is employed in working one of the Blackman Ventilating Company's fans, as well as a complete electric lighting installation.

THE DODGE PATENT WOOD SPLIT PULLEYS.—We have received from Mr. Charles H. Ewen illustrated particulars of these split pulleys. Many advantages are claimed over those generally in use. It is claimed they are 40 per cent. lighter than wrought iron or steel pulleys, and that they give from 25 to 60 per cent. more power with the same belt and tension. The printed particulars also give prices and some testimonials.

FIRES.—We regret to announce that the business premises of Mr. Zimdars, of Gray's Inn-road, W.C., were burnt out a few days ago, Mr. Zimdars being absent at the time, we understand, on the Continent.——On Wednesday the principal portion of the Phœnix Chemical Works at Maryhill, near Glasgow, belonging to the Paterson Chemical Manufacturing Company, was destroyed by fire, and damage estimated at £8,000 was done.

DISSOLUTIONS OF PARTNERSHIP.—Floyd and Stanley, electrical engineers, 2, Victoria Mansions, Victoria-street, London, S.W.; Saunders, Greaves, and Saunders, trading as W. and J. Saunders, electrical appliance manufacturers, 3, Augusta-street, Birmingham.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

May 28, 1891.

9,048. F. COGAN, T. WRIGHT, and R. COLLINS. London. The lighting by electricity of all vehicles drawn by horses, mules, and other animals.

9,073. J. F. MUNSIE. London. Improvements in electric railways.

9,079. C. HOEPFNER. London. Improvements relating to the electrolytic extraction of metals, and to the electrolysis of other substances.

May 29, 1891.

9,103. J. SWINBURNE. Teddington. Improvements in dynamo-electric machines and motors.

9,104. E. W. HARVEY and C. W. ALLDRED. London. Improvements in the manufacture of electric light carbons.

9,107. G. H. BARNES. Birmingham. A connecting union for electric light fittings.

9,145. H. C. L. HOLDEN, B. M. DRAKE, and J. M. GORHAM. Erith. Improvements in electrical measuring instruments.

June 1, 1891.

9,135. T. H. COURTENAY. London. Means for preventing the interference of induction currents of the earth and line wires in telephonic and other electric circuits.

9,190. S. J. DAVIES. London. An improved electric clock.

9,229. SIEMENS BROS. and Co. (LIMITED). London. Improvements in telephones. (Siemens and Halske, Germany)

9,241. W. P. THOMPSON. Liverpool. Improvements in or appertaining to electric railways. (C. K. Harding, United States).

9,245. A. LINHART and C. SEITZ. Liverpool. Improvements in telegraphic apparatus.

9,249. F. J. ROWAN and W. MCWHIRTER. Glasgow. Improvements in electro-magnets for holding tools, lamps, brackets, or other articles, and for telegraphic and other apparatus.

June 2, 1891.

9,291. A. E. BISHOP. London. Improvements in electric arc lamps.

9,299. W. R. SYKES, senior. London. Improvements in apparatus for electrically controlling and registering the movements of keys in connection with railway block instruments, and for other purposes.

SPECIFICATIONS PUBLISHED.

1890.

8,595. GRANVILLE. Electric logs. (Price 6d.)
10,183. LAKE. (Bergmann). Electrical switches. (Price 8d.)
10,768. MUNRO. Electric lamp shades. (Price 4d.)
10,741. SIEMENS BROS. and Co., Limited (Siemens and Halske). Electric glow lamps. (Price 6d.)
10,742. SIEMENS BROS. and Co., Limited (Siemens and Halske). Electric glow lamps. (Price 4d.)
10,743. SIEMENS BROS. and Co., Limited (Siemens and Halske). Electrical conductors. (Price 8d.)
10,806. MILLS (Greenfield). Electrical distribution. (Price 1s. 1d.)
10,857. MUNRO. Electric wire coverings. (Price 4d.)
10,981. WARBURTON. "Arc" lamps. (Price 8d.)
11,042. GOOCH and OTHERS. Electric thermometers, &c. (Price (8d.)
10,052. LANGDON-DAVIES. Telegraph receivers. (Price 11d.)
11,041. ANDREWS. Armoured electric conductors. (Price 8d.)
11,130. FORD. Insulating compositions. (Price 4d.)
11,499. WADLEY. Dynamo electric machines. (Price 8d.)
11,653. HEYS. (Heilmann). Electric propulsion of railway, &c., vehicles. (Price 8d.)
11,883. TOMLINSON. Distributing electricity. (Price 11d.)
11,919. LEGAY, J. and L. Lead wire for electrodes, &c. (Price 8d.)
12,352. BAGNOLD. Electric contact maker. (Price 6d.)
13,853. FAURE. Producing electricity. (Price 8d.)
20,522. HAIGHT. Electrical indicating, &c., system. (Price 1s. 5d.)
20,821. CORNING. Transferring electric car batteries. (Price 8d.)
20,936. WYCKOFF. Electrical signalling. (Price 6d.)

1891.

4,838. BAILEY and WARNER. Incandescent electric lamps. (Price 6d.)
5,135. SOUTHARD. Electric motors. (Price 8d.)
5,192. SCALES. Electric clocks. (Price 8d.)
5,252. GRAFF. Electric railway signal apparatus. (Price 1s. 1d)
5,547. KELLNER. Electrolytic decomposition. (Price 8d.)
5,595. DEWEY. Electric heating apparatus. (Price 8d.)
5,983. LE SUEUR. Electrolysis. (Price 8d.)
6,003. REILLY. Electrical conductors. (Price 8d.)
6,072. CARPENTER. Electro-heating apparatus. (Price 6d.)
6,292. MILLER. Electric insulator. (Price 6d.)
6,881. WALCOTT. Covering electric wires. (Price 8d.)
7,168. WESTER. Voltaic cells. (Price 6d.)

COMPANIES' MEETINGS.

West African Telegraph Company (Limited).

The sixth ordinary general meeting of the Company was held at Winchester House yesterday (Thursday), Sir John Pender in the chair.

The SECRETARY (Mr. William Payton) having read the notice convening the meeting, and the minutes of the last meeting having been read and signed,

The CHAIRMAN said: Gentlemen, you have had the report in your hands some days, and I presume you will take it as read. If so, I shall, as usual, make a few remarks before I ask you to pass the resolution. Our revenue for the year 1890 amounted to £68,377, as against the takings for 1889 of £64,661, showing an increase of £3,716. There has been a growth of traffic throughout the whole line, but the Company's revenue does not expand in the same ratio as the traffic, for the following reasons:—Our receipts from telegrams sent from Portuguese stations are guaranteed by the Government to the extent of £41,900. Our accounts with Portugal for 1890 show that we had to claim only £29,455, and judging from the traffic now passing we shall probably have to claim even less than this sum for the current year. This increase of traffic of course places us in a sounder financial position without, however, increasing our available revenue, the traffic increase coming under the guarantee. With respect to the French stations, the case is different. At these all the money taken is in addition to the subsidies received from the French Government—viz., £12,000 per annum. We also benefit

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by having a share in the revenue derived from telegrams exchanged with the Cape Colony, Orange Free State, Natal, and the Transvaal. Having a joint purse with the Eastern and other companies interested in this traffic, we can always rely on a certain income, even should our cables be interrupted for a time, and in the growth of traffic in this direction we shall participate. The total working expenses for 1890 amounted to £21,685, against £21,155 in 1889, or an increase of £530. Several of the items show decreases and others increases, the principal increase being under the head of working expenses at stations, which this year amounts to £16,511, against £15,666 in 1889—an increase of £845. To add to the comfort of our staff, we have improved the houses at Conakry, Kotonou, and Gaboon by fitting new improved jalousies, and have also considered it necessary to supply those and some other stations with additional furniture, the total cost of which has been charged to revenue. We make a point of keeping our young men as comfortable as possible, and giving them good homes, because unless we do we cannot expect an efficient service. It is always an important consideration that we have an efficient staff, and they are made efficient through our taking great care of them. We have also a full year's working under the agreement with the African Direct Company of the joint stations Bonny and Sierra Leone, against only eight months and six months respectively in the corresponding period. The repairs to cables during 1890 cost £4,788, against £1,780 in the preceding year, or an increase of £3,008. As will be seen from the accounts, the repairs to the Bolama-Bissao cable cost £2.092, and, as explained in the report, we have considered it expedient to pay the sum of £2,500 per annum for the call of a repairing ship when occasion rises. Although the arrangement, so long as the agreement lasts, will cost us £2,500 per annum, it will be found more economical in the end, and our repairs will be done more expeditiously. We are only charged during service on repairs from the time the ship leaves her station abroad, instead of with the expenses of sending the ship from London. It is in contemplation to have the ship specially fitted for this particular service, and to have it nearest places where work will occur. I do not suppose that the cost of the ship, being divided amongst the different companies, would add much to the sum we are paying for the ship. However, that is a question for the experts, Sir James Anderson and others, to decide. We are looking after a ship, but we have not decided upon anything yet. In this year's accounts is included the full annual charge against revenue for interest on and redemption of Five per Cent. Debentures £23,693, against £17,643 for 1889, an increase of £6,050. The annual charge against revenue in future, until all the debentures are paid off, will be the same as appears in this year's accounts. They will all be paid off in 18 years' time. It is proposed to pay a final dividend of 3 per cent., which makes, with the previous interim dividend at the rate of 2 per cent., a total distribution of 5 per cent. for the year, and the balance of £6,015 has been added to the general reserve fund, which, with the interest received on investments to date, now amounts to £26,427. I think, gentlemen, you will agree with me that this is a very satisfactory state of things, maintaining a steady dividend and largely increasing our reserve fund, and it will be the policy of the Board to largely increase our reserve fund, and maintain a steady and substantial dividend. Now, gentlemen, I have given you the hard facts connected with the last year's work, and I will give you now a little bit of the sentiment which always is associated more or less with telegraph enterprise. I think during the last two or three years I have led you on from one step to another, showing that there has been a considerable progress. We have risen from no dividend to a 5 per cent. dividend, which I have referred to more than once, and I have also referred to the great development which must go on in this great continent of Africa. We have met with competition on the part of the Germans, on the part of the French, and on the part of the English. The Portuguese also are showing more energy, but Portugal has been very long associated with Africa, and she has not brought about that development which we would naturally have expected. At the same time our relations with Portugal have been very highly satisfactory. They have paid our subsidies in a very straightforward way, and altogether we have no reason to complain. However, I think it would be to the interests of Portugal, and to the interests of progress, if they were just to part with certain places in which they really cannot make money, but which must cost a good deal. By the sale of these places they would be in a much more comfortable position at home. I believe it would be better for all parties concerned, and I do not think it would rob Portugal of the slightest degree of prestige among the nations. We know exactly the position of Portugal, and she would become richer if she was to pursue the policy suggested. The other countries that are interested in the development of Africa are showing considerable energy, and I am pleased to hear that with Germany we are acting in a very harmonious way, and, therefore, I see large results in that direction. France is also doing a great deal, and though she, perhaps, has a greater idea of her power than other nations, still she has enterprise and energy, and I think benefit will accrue from that energy. We have just sent, or rather there has gone out, one of our distinguished statesmen; he is going to look round, and his observations and influence may stimulate things. We know that the South African Company is one in which there are men of great position and great enterprise. For instance, the Premier of South Africa, Mr. Rhodes, is a man of great energy, and if anything is to be done in Africa he and his friends will do it. I mention these facts simply to lead you to this, that we are ahead of everything. We are there to meet their requirements, and I think if they benefit Africa they must benefit us, and, therefore, I look forward to the future of this Company with very considerable interest and with very great satisfaction. With these remarks I beg to move the first resolution:—

"*That the report and accounts for the year ended December* 31, 1890, *submitted to this meeting be, and they are hereby, received and adopted, and that a dividend be declared payable on and after this date of 6s. per share free of income-tax, making, with the dividend already paid, a total distribution for the year of* 5 *per cent.*"

This was seconded by Sir H. MANCE, and carried unanimously.

It was then proposed by the CHAIRMAN, seconded by Sir JAMES ANDERSON, and carried unanimously:—

"*That Sir Henry C. Mance, C.I.E., and John Denison Pender, Esq., be, and they are hereby, re-elected Directors of the Company.*"

Mr. WELLS then proposed, and Mr. EAST seconded, and it was carried unanimously:—

"*That Messrs. Deloitte, Dever, Griffiths, and Co. be, and they are hereby, re-elected auditors of the Company.*"

Mr. OWEN proposed a vote of thanks to the Chairman and Directors, which was seconded by Mr. JOSEPH T. EAST, and carried unanimously.

The CHAIRMAN: I am sure my colleagues agree with me in thanking you for the acknowledgment of our services. We always feel that the more we can make things satisfactory to the shareholders the more we strengthen our position.

The proceedings then terminated.

City and South London Railway Company (Limited).

An adjourned extraordinary general meeting of this Company was held, on Tuesday last, at Winchester House, Old Broad-street, E.C., Mr. C. Grey Mott presiding.

The CHAIRMAN said: Gentlemen, you will recollect that at the meeting of which this is an adjournment it was agreed that in the interval the Directors should have a conference with some of the larger shareholders of the Company, to see if there were any method that could be devised for raising the additional capital in a better and more economical way than that which had been proposed to you by the Directors. That conference has been held, the matter has been very fully and carefully discussed, and in the result it is agreed by all parties that the recommendation of the Directors made to you is the best and the most economical way of raising the money. It is proposed to slightly modify the resolution, which quite meets with the views of the Directors themselves. Although we create £150,000 of preference shares, it is now proposed that we should be authorised to issue only £50,000. If more money is required, a fresh vote of the shareholders will be asked. It has also been thought desirable that the preference shares should carry with them the ordinary voting power—that is, the same as the ordinary shares have. I therefore propose the first resolution, as follows:—

"*That the resolution passed at the general meeting of the Company, held on the* 12*th of August,* 1890, *relating to the creation of the new capital authorised by the City and South London Railway Act,* 1890, *be, and the same is hereby, cancelled and annulled, except as to the creation or issue of* 5,000 *ordinary shares of* £10 *each, part of the total number of* 20,000 *shares authorised by the said resolution.*"

Mr. HANBURY seconded the resolution, which was carried unanimously.

The CHAIRMAN: The second resolution is:—

"*That* £150,000 *of the share capital, being the balance of the* £200,000 *authorised to be created by the City and South London Railway Act,* 1890, *be, and the same is hereby, created, in* 15,000 *preference shares of* £10 *each, bearing interest at the rate of* £5 *per cent. per annum, and that the Directors be, and they are hereby, authorised to issue* 5,000 *of such preference shares, in such amounts, at such times, and on such terms and conditions, as they may deem fit; the holders of the preference shares hereby created shall be entitled to vote on the same scale of voting as the holders of ordinary shares.*"

Mr. HANBURY seconded the resolution, which was carried unanimously.

The CHAIRMAN, in reply to a question, said that under the Companies Act the shares could not be made cumulative.

The proceedings then terminated.

National Telephone Company (Limited).

The following is the report of the Directors for the year ending 30th April, 1891, to be presented to the shareholders at the eleventh ordinary general meeting of the Company, to be held at the City Terminus Hotel, Cannon Street, London, on Thursday, the 9th July, 1891, at twelve o'clock noon:—

The Directors have the pleasure of submitting to the shareholders the accounts for the year ended 30th April, 1891, showing a balance to the credit of net revenue account of £194,821. 8s. 1d. after providing among other charges for the expenses of issuing the new Debenture Stock, and the accrued interest thereon to 30th April, 1891. Of this amount the sum of £62,973 has been absorbed by the payment of an interim dividend on the preference shares at the rate of 6 per cent. per annum, and on the ordinary shares at the rate of 5 per cent. per annum for the first six months of the year. The Directors propose to pay a further dividend on the preference shares at the rate of 6 per cent. per annum, and on the ordinary shares at the rate of 7 per cent. per annum for the last half of the year, which will absorb a further sum of £86,365. 19s., leaving a balance of £45,482. 9s. 1d. Out of this amount they propose, under Article 113 of the Articles of Association, to transfer to reserve account £40,000, bringing up the amount of the reserve fund to £93,500. There will then remain £5,482. 9s. 1d. to be carried forward to next year.

The extension of the Company's business during the last year has been so large, that notwithstanding the heavy reduction of rates which the

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Directors thought it wise to make in the provinces, in view of the expiration of some of the Company's most important patents, the gross revenue, which last year stood at £411,114. 14s. 1d., reached £418,560. 7s. 8d. on the 30th April, 1891, and is still steadily increasing.

The number of exchange and private line subscribers over the whole of the Company's system, excluding the South of England district, which last year was 29,257, was on the 30th April, 1891, 35,440, an increase of 6,183 subscribers during the year, and the number of subscribers is still increasing. The Directors are still acting upon the conviction that it is of vital importance to continue the policy of developing and improving the Company's system, and of giving greater facilities to the public.

The accrued rental for the year ended April 30, 1890, was £364,704. 17s. 5d. For the present year it is £422,378. 6s. 2d. The working expenses for the year ended April 30, 1890, amounted to £148,457. 0s. 9d., being 40·7 per cent. on the accrued rental, whilst the working expenses of this year amount to £184,056. 9s. 6d., being at the rate of 43·5 per cent. on the accrued rental.

The Directors have taken over the business of the South of England Telephone Company, Limited, which is now merged in this Company.

On the amalgamation, in July, 1889, of the three principal companies, it was thought desirable that the customary annual retirement of one-third of the Directors should not take place at the end of the first year, in order that the numerous arrangements rendered necessary by the amalgamation and reorganisation of the Company might not be interfered with. These having been now completed, and two of the provincial companies, the Northern and South of England Telephone Companies, having been absorbed, the Directors think they ought all, at this meeting, to place their offices at the disposal of the shareholders, and submit themselves for their approval. They, therefore, now all retire, and being eligible, offer themselves for re-election.

The auditors, Messrs. Welton, Jones, and Co., retire, and are eligible for re-election.

NEW COMPANIES REGISTERED.

BABCOCK AND WILCOX (LIMITED).—Registered by Hollams, Sons, Coward, and Hawksley, Mincing-lane, E.C., with a capital of £240,000, in 10,000 preference shares of £10 each, and 14,000 ordinary shares of £10 each. Object: to acquire the undertaking heretofore carried on in London, Glasgow, and elsewhere, other than in the United States of America and the Island of Cuba, by the Babcock and Wilcox Company of New York, in accordance with an agreement expressed to be made between the Babcock and Wilcox Company of New York, of the one part and the Company of the other part, and to carry on business as manufacturers of water-tube steam boilers, and generally the business of engineers and manufacturers of machinery of every description.

GLOUCESTER ELECTRICITY SUPPLY COMPANY (LIMITED).—Registered by Sydney Morse, 4, Fenchurch-avenue, E.C., with a capital of £100 in £1 shares. Object: to carry on business as electrical engineers, electricians, &c. Most of the regulations of Table A apply.

MIDDLESBOROUGH ELECTRICITY SUPPLY COMPANY (LIMITED).—Registered by Sydney Morse, 4, Fenchurch-avenue, E.C., with a capital of £100 in £1 shares. Object: to carry on generally the business of electrical and mechanical engineers, &c. The regulations contained in Table A mainly apply.

QUEEN ANNE'S MANSIONS LIGHTING AND HEATING COMPANY (LIMITED).—Registered by Paine, Son, and Pollock, 14, St. Helens-place, E.C., with a capital of £60,000, in £10 shares. Object: to adopt and carry into effect an agreement expressed to be made between William Robert Renshaw of the one part, and this Company of the other part, and to carry on, in the city of Westminster and elsewhere (and in particular at Queen Anne's Mansions, Westminster), the business of an electric and gas lighting, heating, and power company in all its branches.

ROCHDALE ELECTRICITY SUPPLY COMPANY (LIMITED).—Registered by Sydney Morse, 4, Fenchurch-avenue, E.C., with a capital of £100 in £1 shares. The objects of this Company are sufficiently indicated by the title. With slight modifications, the regulations contained in Table A apply.

STOKE-ON-TRENT ELECTRICITY SUPPLY COMPANY (LIMITED).—Registered by Sydney Morse, 4, Fenchurch-avenue, E C., with a capital of £100 in £1 shares. Object: to carry on the business of an electrical engineer in all its branches. Most of the regulations contained in Table A apply.

WYLIE, BROWN, AND CO. (LIMITED).—Registered in Scotland, by Mr. Thomas Neilson, solicitor, Glasgow; capital, £1,000 in £1 shares. Object: to take over from the trustee of the sequestrated estate of Wylie, Brown, and Co., West-street, Tradeston, Glasgow, the goodwill of the business, the whole of the plant, stock-in-trade, outstanding accounts, remainder of the lease, and all assets of that firm, and to carry on the business of iron, brass, and steel founders, and general founders and engineers, in continuation or extension of the business hitherto carried on by that firm.

CITY NOTES, &c.

BOURNEMOUTH AND DISTRICT ELECTRIC SUPPLY COMPANY (LIMITED).—A prospectus of this Company has been issued by the Electric and General Investment Company (Limited), inviting subscriptions for 6,000 shares of £5 each, payable 10s. per share on application, 10s. on allotment, £1 on August 1 next, £1 on September 1st next, and the balance in calls not exceeding £1 at intervals of not less than three months. The Company is formed to undertake the supply of electric light and power in Bournemouth, and to take over the existing central station, business, and undertaking under the Provisional Orders now being worked by the Brush Electrical Engineering Company in Bournemouth. A map is issued with the prospectus showing the area supplied by the undertaking, and the Bournemouth Company takes over the existing plant, erections, and goodwill and interest of the Brush Company. The station, plant, and circuits have been inspected by Prof. J. A. Fleming, whose report is appended to the prospectus. The managing director of the Company is Mr. H. W. Wollaston, the secretary is Mr. Charles Offer, and the offices are Observer-chambers, Albert-road, Bournemouth. The lists opened on Monday and closed yesterday for both town and country.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the past week amounted to £5,653.

CITY AND SOUTH LONDON RAILWAY COMPANY.—The traffic receipts of this Company for the past week amounted to £697. The aggregate receipts for the half-year to date are £19.197. Mr. H. H. M. Smith has resigned the position of secretary to this Company, and has been succeeded by Mr. W. F. Knight.

CUBA SUBMARINE TELEGRAPH COMPANY.—The estimated traffic receipts of this Company for the month of June were £3,500, as compared with £3,324 in the corresponding month of last year.

EASTERN TELEGRAPH COMPANY (LIMITED).—The Company announce that, subject to final audit, the accounts show, after placing about £95,000 to reserve fund, a balance available sufficient to pay at the general meeting, on 16th July inst., the fixed dividend of 3s. per share, being at the rate of 6 per cent. per annum on the preference shares, less income tax; and a final payment of 2s. 6d. per share, with a bonus of 3s. per share, both free of income tax, on the ordinary shares, making with previous payments on account, a total distribution of 6½ per cent. on those shares for the year ended 31st March, 1891. The transfer books of the Company will be closed from the 9th to 16th July, both days inclusive.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY (LIMITED).—This Company has declared an interim dividend for the quarter ended March 31st last of 2s. 6d. per share, payable on the 15th instant.

HALIFAX AND BERMUDAS CABLE COMPANY (LIMITED).—The coupons of this Company's Four and a-Half per Cent. First Mortgage Debentures, due June 30, 1891, will be paid on and after that date by Messrs. Prescott, Dimsdale, and Co. (Limited), 62, Threadneedle-street, E.C.

QUEEN ANNE'S MANSIONS LIGHTING AND HEATING COMPANY (LIMITED).—The prospectus of this Company has been issued this week by the Electric and General Investment Company, in conjunction with the Gas, Water, and General Investment Trust (Limited). The present issue is for 430 Six per Cent. First Mortgage Debentures of £100 each. The Company is formed with a capital of £60,000, divided into 3,000 Four and a-Half per Cent. Cumulative Preference Shares of £10 each, and 3,000 ordinary shares of £10 each. These shares are, however, not for subscription. The debentures are payable as follows:—£35 per cent. on application, £35 per cent. on allotment, and £30 per cent. on September 1st next. The consulting engineer to the Company is Mr. J. S. Raworth, M.I.E.E.; the secretary is Mr. J. A. Kelman. The Company is formed for the purpose of taking over and working the contract for the heating and the supply of electric light and hydraulic power to the large block of buildings known as Queen Anne's Mansions. Accompanying the prospectus is a report from Mr. Raworth. The lists closed yesterday (Thursday) at four o'clock. The prospectus stated that the figures upon which the estimated profits are calculated "do not include any profit to be derived from the supply of electric light and power to any other buildings and places in the same neighbourhood, which it is believed can be undertaken by the Company with good results." In reference to this clause, Mr. Bax, the manager of the Westminster Electric Supply Corporation, wrote to the *Financial News* of Wednesday as follows:—"It is but right that the public should be made aware that Parliamentary powers for the supply of electricity in the district in which Queen Anne's Mansions are situated have as yet only been granted to one supply company, viz., the London Electric Supply Corporation (Limited), and that, as similar powers are this session being conferred upon the Westminster Electric Supply Corporation (Limited), there is no probability of the Queen Anne's Mansions Lighting and Heating Company being authorised to supply electric light and power beyond the area covered by the mansions themselves." To this Mr. Kelman replied, in the next issue of our contemporary, that his company had "a large present and profitable revenue quite independent of Parliamentary powers, something a little more substantial than 'similar powers being conferred' for the supply of electricity."

ST. JAMES AND PALL MALL ELECTRIC LIGHTING COMPANY (LIMITED).—The Directors have declared an interim dividend at the rate of 7 per cent. per annum for the half-year ending June 30th, payable in the first week of July. The transfer books will be closed from the 1st to 10th July, both inclusive.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The following are the traffic receipts of this Company for the past four months:—March, £3,250; April, £600; May, £1,275; June, £1,575. The southern cables are still interrupted owing to the revolution in Chili.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended June 26, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brasilian Telegraph Company (Limited), were £3,833.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, June 24.		Price Wednesday, July 1.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending July 1.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS.								
£1,300,980	Stock	12/0	Anglo-American	46	47	45½	46½	6 2 7	Jan., Apr., July, Oct.	46½	..
£2,849,510	Stock	21/0	Do. Preferred	84	85	84	85	6 15 4	" "	84½	83½
£2,849,510	Stock	..	Do. Deferred	11	11½	10¾	11½	.. ..	.. ..	..	..
£250,000	100	4%	African Direct, Telegraph 4% Debentures ....xd	99	102	97	100	4 0 0	January and July ..	..	..
130,000	£10	3/0	Brazilian Submarine.....xd	11¾	12½	11⅛	12	7 1 8	Mar., June, Oct., Dec.	12½	11 7/16
£69,200	£100	5%	Do. 5 per Cent. Bonds	101	104	101	104	4 16 2	January and July ..	102½	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)..xd	104	108	103	107	4 13 6	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock .....xd	106	108	103	107	6 6 2	April and October ..	..	..
16,000	10	8/0	Cuba Submarine	10½	11½	10½	11½	6 19 2	February and August	10¾	..
6,000	10	10%	Do. Preference 10%	16¾	17¾	17	18	5 11 1	" "	16¾	..
12,931	5	3 3/20	Direct Spanish (£4 paid)	3¾	4¼	3¾	4¼	6 11 9	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	10¾	10¾	10½	10¾	6 10 3	Jan., Apr., July, Oct.	..	..
400,000	10	2/6	Eastern	14¼	14¾	14⅜	14¾	4 7 5	" "	14¾	14 5/16
70,000	10	6%	Do. 6 per Cent. Preference	15	15½	15	15½	3 17 5	" "	..	..
£1,200,000	Stock	6%	Do. 4 per Cent. Mort. Debenture Stock	106	109	106	109	3 13 5	May and November	107	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 10 11	February & August	109½	107½
250,000	10	6/6	Eastern Extension	14¾	15½	14¾	15½	4 11 10	Jan., Apr., July, Oct.	15½	15
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock	105	108	105	108	3 14 1	.. ..	..	..
£85,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 ..xd	103	106	101	104	4 16 2	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900 xd	103	106	101	104	4 14 4	" "	105	..
180,227	10	2/6	Globe Telegraph and Trust	9⅛	9¾	9⅛	9¾	5 5 1	Jan., Apr., July, Oct.	9¾	9 7/16
180,042	10	6%	Do. 6 per Cent. Preference	15	15½	15	15½	3 18 8	" "	15 5/16	14⅛
150,000	10	8¾% fr 90	Great Northern .....xd	18½	19	18½	18¾	4 10 8	Jan., April, and July	18½	18½
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	106	108	105	108	4 12 7	March & September	..	..
17,000	25	37/6	Indo-European	39	41	39	41	4 11 6	May and November	40½	40
38,348	10	5,0	London Platino-Brazilian	6¾	7⅛	6¾	7⅛	6 0 0	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106	109	106	109	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's	8	8⅛	8	8⅛	4 14 1	April and October..	7⅞	..
3,351	£100 Cert.	6%	Submarine Cables Trust 6%	113	117	114	118	5 1 8	" "	116½	115½
15,609	10	4/0	West African Telegraph	8	9	8	9	5 11 1	January and July ..	..	..
£281,400	100	5%	Do. 5 per Cent. Debentures	95	98	95	98	5 2 0	March & September	..	..
30,000	10	2/0	West Coast of America	3½	4½	3½	4½	..	January and July ..	..	..
£150,000	100	8%	Do. Debentures 8% 1902.....xd	100	105	96	101	7 18 5	June and December	..	..
88,321	10	9d.	West India and Panama	2⅜	3	2⅜	2½	..	..	2 7/16	2⅜
34,563	10	6/0	Do. 6 per Cent. 1st Preference	10½	11	10	10½	5 14 3	May and November	10	..
4,669	10	34/6	Do. 6 per Cent. 2nd Pref.	9½	10½	9	10	6 0 0	" "	..	..
61,633	15	9/0	Western and Brazilian	11½	11¾	11½	12	6 5 0	" "	11¾	11
30,364	7½	1/6	Do. 5 per Cent. Cumulative Preferred	6½	7	6½	7	5 7 3	" "	..	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	4½	5	4½	5	..	..	4½	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103	106	103	106	5 13 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1916	103	106	103	106	5 13 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117	122	117	122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bond	100	104	100	104	5 15 5	March & September	..	..
			TELEPHONES.								
224,850	14/0	0/4½	Consolidated Telephone Const. & Maintenance...	1/16	1/8	1/16	1/8	7 9 4	May and November	..	..
220,000	£1	4·76	Oriental (11s. paid)	⅛	¼	⅛	¼	5 2 11	Yearly	..	..
438,984	5	6%	National	4¾	5⅛	5	5⅛	5 14 3	June and December	5⅛	4 15/16
15,000	10	6/0	Do. 6 per Cent. Cumulative 1st Pref.	12½	12⅝	12½	12⅝	4 14 1	" "	12⅝	..
15,000	10	4/9⅜	Do. 6 per Cent. Cumulative 2nd Pref. (£8pd) ..	12	12½	12	12⅝	3 16 10	" "	12	..
350,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd) ..xd	104	106	103	105	4 5 9	..	105⅛	103⅛
58,000	5	1/0	United River Plate	2½	3½	2½	3½	..	January and July ..	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock .....xd	85	95	85	95	5 5 8	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
1,000	£50	..	City of London Electric Lighting Shares (£25 pd)..	36	37	36	37	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	4½	5	4½	5	..	..	..	..
5,322	£5	..	House to House Electric	4½	5½	4½	5½	..	..	..	..
30,000	£5	..	Liverpool Electric Supply (£3 paid)	2½	2¾	2½	2¾	3 13 1	..	..	..
111,000	5	..	London Electric Supply	1⅞	2⅛	2	2⅛	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	9½	10½	9¾	10½	4 7 7	..	10 1/16	9¾
7,730	£5	..	St. James' and Pall Mall	5½	6⅛	5½	6⅛	..	..	..	..
..	..	7%	Do. 7% Preference	¾	1 prem	¾	1	..	..	..	..
42,853	5	..	Westminster Electric Supply (£5 paid)	4½	5½	4½	5½	..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978		..	Brush Electrical Engineering	2⅜	2⅝	2⅜	2⅝	..	..	..	..
69,996	2	1/1	Do. 6 per Cent. Preference	1⅝	1⅞	1⅝	1⅞	6 8 0	June and December	1 15/16	1⅞
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	4	5	4	5	7 0 0	January and July ..	..	..
17,130	5	..	Edison and Swan United	..	..	..	..	..	..	..	..
45,000	10	6%	Electric Construction	3½	4½	3½	4½	..	..	..	..
70,000	2	10/0	Elmore's Patent Copper Depositing	3	3½	3½	3½	..	..	3	3
20,000	5	..	Fowler-Waring Cables (£4 paid)	2	3	2	3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works...	18½	19½	19	20	5 0 0	February & August	19¾	19½
£300,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	105	103	105	4 5 9	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	7⅛	8½	7⅛	8½	11 15 3	..	..	..
11,334	£10	5/0	Do. Preference	9½	9¾	9½	9¾	8 4 1	..	..	..
78,949	5	2/1½	Swan United (£3. 10s. paid)	4⅜	5	4⅜	5	6 19 10	May and November	4½	..
37,350	12	36/0	Telegraph Construction and Maintenance	46	48	46	48	5 0 0	March and July.....	46½	46
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894.....xd	103	106	101	104	4 16 2	January and July ..	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£3 paid)	2½	2⅝	2½	2⅝	..	..	..	..
—	£5	..	Do. Preference (fully paid)	3⅝	4⅛	3⅝	4⅛	..	..	..	..
			RAILWAYS.								
50,000	£10	..	City and South London Railway	4	5	4	5	..	..	..	..

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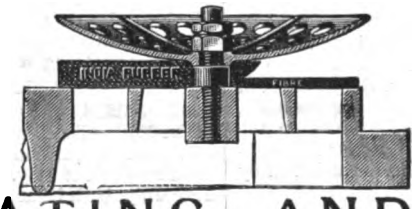
No Rubber, Percha, or Leather.



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"12, John-street, Sunderland, 26th Sept. 1885.

"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue get them from you as required.—Yours faithfully, JAMES WESTOLL."

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

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NOTES.

The Incorporated Association of Municipal and County Engineers have plenty of food for study in the two Papers which have been read to them by Mr. Preece and by Prof. H. Robinson. Both of these require a little digestion, and if Mr. Preece provided a more palatable discourse, Prof. Robinson perhaps offered more nourishment. Mr. Preece was in a rather optimistic mood, and argued that because a unit of electrical energy can be produced for industrial purposes for one-third of a penny "it is equivalent to gas produced at threepence per thousand feet," and that this "shows what a vast field of development is before electric light." He points out that the load factor—that is to say, the variable and brief supply during the day accounts for much, but in his recent Paper on Mains (*The Electrician*, May 29, p. 109) he gave a more important reason for the difference between this figure and the usual selling price. "If we can reduce the cost of distribution and its up-keep by 50 per cent., we should be able to supply light by electrical energy more cheaply than by gas." The one-third of a penny would sometimes purchase a hundredweight of fresh herrings, but not for delivery at one's door in London. The load factor difficulty might be overcome by the use of batteries, if these could be made to redeem the promises made for them by their inventors and manufacturers.

Mr. Preece has been somewhat criticised in the gas journals, as might be expected, for giving the low figure of 10 candles as the light of "an ordinary burner, supposed to be consuming 5ft. per hour," and the Paper of Prof. H. Robinson, of which an abstract will be found in another column, contains figures relating to large and improved burners, in which "flat flames in clusters" are said to yield as much as five candles per cubic foot per hour. But, so far from admitting that these figures disprove those of Mr. Preece, we would point out that hundreds of miles of streets are lit with these miserable flickering jets, and that it is the competition of electric light which is inducing the gas engineers to arouse themselves, and to provide here and there a few more efficient burners. When the 10-candle burner becomes the exception rather than the rule, the public will have to thank electric lighting for the change.

It is very satisfactory to find in Prof. H. Robinson's Paper that some attention is paid to the matter of illumination, which is the ultimate object of electric light, but which receives very little attention from engineers. The author speaks of the angle at which the light falls as the angle between the ray and the horizon; but, in optical science, the angle of incidence is always taken as the angle between the ray and the perpendicular to the surface. Thus, the ray striking the ground below the lamp is said to have no inclination, or an angle of incidence of 0. The illumination of a surface is proportional to the cosine of this angle of incidence, and if we accept the author's mode of reckoning it would be proportional to the sine of his angle. But he says, "the light falling on a unit area of pavement varies inversely as the square of the distance from the lamp, and is directly proportional to the angle at which it falls," and he goes on to remark that "this angle is nearly proportional to the height of the lamp divided by the distance." It is not clear whether this means the horizontal or the slant distance from the lamp. The latter is correct.

In giving the candle-power of arc lamps at different angles, Prof. H. Robinson speaks of the candle-power at an angle of 20deg. (from the horizontal) as representing a fair average of the power from arc lamps. This is, doubtless, true, but not very clear; for it suggests that the ray falling at this angle gives an illumination on the pavement which is the average of the surrounding illumination. This is far from the case; for, owing to the distance from the lamp and the inclination of the ray, the illumination would be only ·04 of the maximum; that is, of a vertical ray. We hope that Prof. Robinson will give further attention to this important subject, and put into practice at St. Pancras some of the very practical suggestions contained in his Paper.

The progress of electric traction in this country is slow but sure. So slow that the Cantor lectures delivered by Mr. Kapp in February last have not become stale on account of recent developments; and so sure is it that at the recent meeting of the Tramways Institute the general feeling of the meeting and the opinion of the chairman were strongly in favour of the use of the electric motor. The Cantor lectures, which, according to our custom, we reproduce in full, deal very carefully with electric traction, and little, if any, new information as to actual cost of working in this country have been published since these lectures were given. We neglect American figures because the conditions are so different that it is impossible to accept them as a guide. Our readers will remember that in February last we commented on some figures which were then given by

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Mr. KAPP, relating to the Barking Road line, and that the Company who are now working these cars strongly objected to the conclusions which were drawn from them. Mr. KAPP, forgetting or being unaware that his informant had been connected with, and had derived his data from, the working of another traction company, withdrew the obnoxious figures, but we regret that no authorised statistics have been given in their place. We shall reprint this part of the Cantor lecture next week, and should be glad to append the authentic figures. The future development of electric traction is largely a question of operating expenses per car mile, but it appears that the receipts of the three miles at Birmingham, on the Bristol road, show that the electrical cars are more popular than the horse cars, as is indicated by the takings of 9·29d. per mile by the latter, against 14·26d. per mile by the former. Thus we may expect that even while electric traction costs more than horse traction, it may compete with it on account of greater comfort and convenience, just as electric light successfully competes with gas for these reasons.

IN a recent number of the *Comptes Rendus*, Mr. MICULESCO describes a new determination of the mechanical equivalent of heat, by a method essentially the same as that originally used by JOULE, but embodying several improvements in detail. The power used in turning the paddles was measured more directly at the place of application. It was supplied electrically by a motor supported at the middle of the beam of a balance, and the moment exerted in turning the paddles could be measured by adjusting the weights in the scale pans. This moment, when multiplied by the revolutions of the motor, gives the power expended in churning up the liquid, independently of any friction taking place in the motor itself; while in the analogous experiment of JOULE the friction of the cord and pulleys produces a slight error in the estimate of the power. Another improvement consisted in the exertion of much greater power than in JOULE's measurements. The electric motor was of the Gramme type, having an output of 1 H.P., so that heat was quickly generated. Errors due to radiation were eliminated by working between temperatures but very slightly different from that of the surrounding atmosphere, while errors caused by uncertainty about the water equivalent of the apparatus were altogether avoided by adjusting the flow of water into, and out of, the calorimeter till the temperatures of the influx and efflux were constant. The difference of temperatures was read with great accuracy by means of a thermo-electric couple, previously calibrated against a standard thermometer. The value, 426·7, found for the mechanical equivalent of heat, is exceedingly close to JOULE's number, which, when reduced to correspond with the air thermometer at Paris, is 426·5. The value, 772, is, perhaps, more familiar to our readers as the number of foot-pounds required to heat one pound of water 1°F. The new determination in such units would be 772·3. It may be remembered that Messrs. COOPER and ANDERSON conducted some experiments on a large scale in 1887, and arrived at the value 769, but it is not at all clear that their method was free from essential errors in the arrangement of the apparatus, or from errors due to radiation and conduction. Prof. MARKS, in 1885, obtained the number 772·8 by experiments made with the "Tatham Dynamometer." Perhaps the chief interest of the results of MICULESCO and MARKS is their proof of the extraordinary accuracy with which JOULE worked.

IN our obituary notice of Prof. WEBER, the word "re-invented" was used in connection with Sir WILLIAM THOMSON's application of the mirror for indicating the deflections of a galvanometer. There was no re-invention. GAUSS and WEBER employed mirrors weighing several ounces in their magnetometer work, but their arrangement was suitable only for showing very slow changes. HELMHOLTZ reduced the weight of the mirror to about an ounce; and, in a Paper communicated to the Royal Society about 1855, and republished in Vol. II. of his collected Papers, Sir WILLIAM THOMSON refers to HELMHOLTZ's instrument as his starting point. This was still much too heavy for submarine telegraphy; and no instrument was in existence which would give a continuous indication of the change in direction of the small currents which constitute cable signalling, and which was capable of following their variations continuously, until a reflecting galvanometer was provided having a mirror and attached needle, weighing only half a grain in all, in THOMSON's original submarine telegraphic mirror instrument.

THE communication by M. ANDRÉ to the Academie des Sciences, on the study of atmospheric electricity, a translation of which we print in another column, should encourage the attempts of rain-makers. The author finds that the curves of the weight of water vapour are sensibly parallel to those of electric potential; but the former appear to lag behind, and, therefore, may be assumed to be the effect of which the electric changes are the cause. We presume that no rain-maker attempts to create aqueous vapour, but pretends to precipitate it in the form of a shower. There are sound reasons for supposing that such precipitation can be produced by electrical discharges, but it is difficult to calculate the scale on which such discharges should be carried out. A WIMSHURST machine on the scale of FERRANTI's largest dynamo might serve for the four-mile radius, but who would decide when it should be used? The County Council would doubtless be ready to place the matter in the hands of a Committee, though it would, perhaps, be better for the Government to appoint a Minister of Meteorology. We do not envy the responsibility which would attach to the post during Henley week.

Personal.—Mr. Alfred E. Ruddock, who has been for some years with Messrs. Goolden and Co., has joined the staff of Messrs. Poole and White.

Vienna.—It has been decided to light the Bourse by electricity; arc lights are to be used in the halls and vestibules, and incandescents in the rooms.

Telephone Trunk Wire Development.—A third telephone wire is now being erected between Paris and Brussels, and the line is being extended to Antwerp.

Littlestone-on-Sea.—This seaside resort, between Dungeness and Folkestone, has been granted an Act of Parliament for the erection of a pier and an electric tramway.

Telephone Trunk Wires in South Germany.—The telephone line between Munich and Stuttgart (125 miles) started working on the 1st inst. One shilling is charged for five minutes' conversation.

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Electric Railway in Württemberg.—According to the *Elektrotechnischer Anzeiger*, the Municipal authorities of Württemberg have decided on building an electric railway between Meckenbeuren and Tettnang.

Arco.—The Town Council of Arco have commissioned Messrs. Kremenezky, Mayer and Co., of Vienna, to light the town by electricity. Continuous current 150 volt dynamos, driven by turbines, will run glow lamps for the street lighting.

Proposed International Electrical Exhibition at Melbourne.—It is proposed to hold a large International Electrical Exhibition at Melbourne about the end of the present year. The Exhibition will be held in the building used for the Centennial Exhibition of 1888.

City and Guilds of London Institute.—The next entrance examination for the Central Institution will be held on September 21—24th; and for the day department of the Finsbury Technical College, on September 29th. Further particulars will be found in our advertisement columns.

Projected Electric Railway in Italy.—*L'Eletricità* states that a project for the construction of an electric railway from Aosta to the borders of France and Switzerland at Pre Saint Didier, a distance of between 20 and 30 miles, has been laid before the Italian Minister of Public Works. This would be by far the longest electric railway in Europe. Water power would be employed.

Clerkenwell Vestry.—At the last meeting of this Vestry a letter was read from the Brush Electrical Engineering Company, giving notice of their intention to apply for a Provisional Order to supply electricity within the area of Clerkenwell. Similar letters were read from the County of London Electric Lighting Company and the Camberwell and Islington Electric Light and Power Company.

Electric Signalling at Henley.—At the Henley meeting, this week, a new departure was made by the adoption of electric signalling, in addition to the big bell on Frog Island, and the firing of a gun at the starting of each race. To every fifth pole on the Berks side of the river an electric bell was attached, which was set ringing two minutes before the start, and stopped the moment the oars touched the water.

The Electrical Equipment of the ss. "Scot."—In a paragraph on this subject in *The Electrician* of 26th ultimo it was stated that the measuring instruments of the "Scot" had been supplied by Messrs. Siemens Brothers. We are asked to modify that statement to the extent of saying that the voltmeters used in the "Scot's" electrical equipment are of Sir Wm. Thomson's marine type, and were made and supplied by James White, of Glasgow.

Burton.—At a recent meeting of the Town Council, the Gas and Electric Lighting Committee presented a report in which they asked permission to proceed to carry out the provisions of the Burton-upon-Trent Electric Lighting Order, 1890, to obtain a site for electric lighting works, and to advertise for tenders and proposals for electric lighting systems, the execution of works, and the supply of machinery, at a fixed sum. The report was adopted.

Anti-Magnetic Alloys for Watches.—The following names have been given to alloys suitable for manufacture of anti-magnetic watches:—(1), Mangor, an alloy of manganese and gold; (2), volfor, an alloy of wolfram and gold; (3), woltine, a gold platinum alloy; (4), cadmine, a hard and very elastic cadmium compound; (5), aror, an alloy of gold, cadmium, and manganese; (6), manium, an alloy of manganese, platinum, bismuth, and copper.

Electrical Bills in Parliament.—The London County Council's Overhead Wires Bill received the Royal Assent on Friday last. Petitions praying to be heard against the London County Council General Powers' Bill, when it reaches the Committee stage of the House of Lords, have been presented by the London Electric Supply Corporation and the Westminster Electric Supply Corporation.

Institution of Electrical Engineers.—The annual *conversazione* of the Institution of Electrical Engineers was held, on Monday evening last, in the galleries of the Royal Institute of Painters in Water Colours, Piccadilly. About 800 guests accepted the invitation of Prof. Crookes and Mrs. Crookes. Amongst those present were:—Sir F. Abel, Sir J. Douglass, Sir W. Thompson, Sir Benjamin Baker, Sir Philip Magnus, Sir E. J. Reed, Dr. Hugo Miller, and Herr Ganz.

Insulating Suspension for Arc Lamps.—A swivel suspension insulator has been designed by Mr. J. Raeburn, of Glasgow. A hollow casting, not unlike an inverted inkpot, contains five balls of glass or porcelain, and these form a ball bearing for a hook on which the lamp hangs. The insulation of such a swivel should be good, as the balls are well protected; but a shackle is generally sufficient, and a swivel would frequently giev trouble by allowing the leads to twist together.

Hampstead Vestry.—The draft Provisional Order prepared by the Electric Lighting Committee of this Vestry will be discussed on the 22nd inst. Notices have been served by the following companies of their intention to apply to the Board of Trade for Provisional Orders to supply electricity in this parish, viz.:—The House-to-House Electric Light Supply Company, the Hampstead Electric Light and Power Supply, the Hampstead Electric Supply Company, and the County of London Electric Lighting Committee.

The City Lighting.—At the last meeting of the Commissioners of Sewers, the Clerk said he had received a notice from the Brush Electrical Engineering Company of their intention to apply for a Provisional Order authorising them to supply electrical energy for public and private purposes within the City of London. Also a notice from the Laing, Wharton, and Down Construction Syndicate, of their intention to apply for a Provisional Order authorising the said Syndicate to amend the City of London (East District) Electric Lighting Order, 1890.

Railway Electric Lighting Plant.—At the Government dockyard at Port Adelaide there is in course of construction a travelling electric light plant for use on the railways. It consists of an ordinary locomotive engine, a truck upon which is fitted a portable engine and the dynamo, and the weed-stripper, which is used for clearing the railway lines of undergrowth. The plant, when completed, will be used to enable the navvies to carry on their work as much as possible at night, when their operations will be less hampered by the train traffic than during the day. Telegraph poles, upon which the wires are carried and the lamps hung, will be erected at each halting-place where their services are required.

Electricity in Collieries.—Electricity, says the *Colliery Manager*, has again given a most satisfactory account of itself as a valuable adjunct to coal-mining plant. Recently a very large feeder of water broke away at one of the pits of the East Howle Colliery, Ferryhill. If it had not been for the good service rendered by the new electric plant, lately supplied by Messrs. Mercier, Corlett, and Co., Wigan, one seam must have been drowned out. The pump ran for 82 hours, only stopping twice in 24 hours, and then for a few minutes, only to change brushes. In that time, Mr. Henry Palmer, the manager of the colliery, informs us it pumped 2,700,000 gallons, or equal to 12,000 tons of water.

Electric Launches on Lake Windermere.—Several launches have been introduced on to Lake Windermere by the General Electric Power and Traction Company. The boats are those which plied at Edinburgh during the Exhibition, and have a light and graceful appearance on the water. Each is 40ft. in length, 6ft. 6in. beam, and licensed to carry 40 passengers, the speed attained being about eight miles an hour. The seats run the entire length of the vessels, beneath which are the storage batteries. The dynamo for generating the power required is erected near to Cockshott Point, and is driven by a 16 H.P. Roby steam engine, and, in addition to this, the water power of a neighbouring mill has been secured.

Hove.—In January last the Hove Commissioners decided that the electric lighting of Hove should be carried out by a transfer of the powers under their Provisional Order to some responsible company, and that an electrical engineer should report on the best system to be adopted, specify the plant required, and should advise as to the terms to be offered to a company. Mr. Crompton was the engineer selected, and the Electric Light Committee has had many meetings on the subject. The result is a report which was to come before the Commis-

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sioners yesterday. The Committee are of opinion that the three-wire system, with storage, should be adopted. On the subject of plant the Committee rely upon Mr. Crompton's recommendations.

Rapid Transit in Cities.—In the discussion of a recent Paper read before the American Institute of Electrical Engineers on rapid transit in cities, Prof. Forbes called attention to the fact that the English had apparently outstripped the Americans in rapid transit matters. "We have heretofore called attention," says the *Western Electrician*, "to the progress that has been made on the other side, especially in the London underground system. It appears that our friends across the water are thoroughly enjoying the situation, and taking all the comfort possible from the thought that they have at last surpassed their American rivals. One cannot wonder at this. It is a rare spectacle, and probably the one occasion of a lifetime for our English friends."

Brighton.—The works in connection with the electric lighting of Brighton by the Corporation are rapidly approaching completion. The generating station in North-road is practically finished. In the boiler-house there are three mild steel Lancashire boilers, and there is space for another set. In the engine-room there are four 165-unit dynamos, coupled direct to Willans engines. Overhead there is a 6-ton travelling crane. In the engine-room space has also been reserved for doubling the number of dynamos and the engines. In the battery-room the stands to receive the accumulators have been placed in position. The street mains comprised in the existing scheme have all been laid, with the exception of the branch passing along the Western-road to the western boundary of the borough.

The Frankfort Exhibition.—The following circular has been sent by the Secretary of the London Chamber of Commerce to members of the Electrical Trade Section :—

Dear Sir,—At the recent meeting of the Electrical Section of this Chamber, one of the subjects discussed was the formation of a party to visit the Frankfort Exhibition. It was generally felt that there were greater privileges and facilities afforded in the way of guides, &c., when the visit took the form of a representative party than there would be in the case of a visit as private individuals. The authorities of the Exhibition have been communicated with, and have expressed themselves favourably towards the proposed visit, which would probably extend from the 5th to the 15th of September. With the view of determining whether the visit can be made in the form of a party, I should be pleased to hear from you at your earliest convenience as to whether you propose to visit this Exhibition or not, and, if so, whether you would wish to become one of the party, and if the date named (5th to 15th September) would be suitable for you.

The Chicago Exhibition.—In the House of Commons last week, Mr. Grotrian asked the Under-Secretary of State for Foreign Affairs whether the report was true that the Government intended spending on the Chicago World's Fair an amount less than half the sum set apart for the Paris Exhibition; and whether it was their intention to give the management of the British section to the Society of Arts, and not to a Government department. In reply, Sir J. Fergusson stated that the arrangements were not made by the Foreign Office; but he believed that provision was likely to be made for a Royal Commission to provide for the representation of this country at the Chicago Exhibition at a lower cost than at the French Exhibition of 1878.

Aluminium.—With the price of aluminium reduced only a very little from present rates, says the *Mining Journal*, there is a strong probability of aluminium-bronze very largely displacing brass. A small percentage of aluminium to Babbitt metal gives results which in many classes of work are largely superior to those obtained from ordinary Babbitt metal. Aluminium is being largely adopted as a material in the railroad shops of the United States. It is being employed in the construction of the valves to control the passage of the air from the storage cylinders to the brake cylinders in the new and larger form of the Westinghouse brake; and for this purpose its lightness gives it an important advantage over the heavy iron or brass slide valves. The valves of the pure metal in sample castings appear to have satisfactorily answered their purpose, and, with the addition of a little copper, there is no question of the efficiency of aluminium in this and other engineering employments.

Electric Traction in Boston.—Electric traction is apparently a success in Boston, if we may judge by the following extract from a Boston technical contemporary :—"With the electromotive force and the palatial street-car equipment now on our streets, Boston can vie with any system of street-car traction on the continent. A system thoroughly established by masterly effort and unswerving energy, measured by public appreciation and a greatly increased patronage, the West End system rests upon an assured stability that places it as the foremost street-railway property in this country. Statistics are not wanting to prove the greatly increased traffic of the West End system. The evidences are in sight. The popular clamour to ride in a palatial street car is heard and seen on all our avenues and throughout all of Boston's suburbs, proving the advantages of the subtle element, the unseen power of quick transit, and the ability given the Company to cope with the demands of an ever-increasing population."

Telluric Non-Conducting Cement.—In the present day of small profits, says the *Chemical Trade Journal*, it has become necessary for all those who require steam as a means of heating and power to obtain their steam under those conditions which develop the maximum efficiency of the boilers. The importance of giving due attention to the covering of boilers, and steam-pipes in particular, is especially great in works where the steam has to be conveyed long distances. The enormous loss of steam, owing to condensation in such cases, is alarming. A non-conducting medium must not only be an efficient non-conductor, but must also set well, without cracking, be impervious to the action of rain and atmospheric influences, neither fire nor char, and last, but not least, the price must be within reason. Telluric cement combines these properties as much as is possible. It is strong and adhesive, and sets firmly, and, therefore, in all cases where vibration is likely to occur it is eminently suitable. As regards its non-conducting properties, it is admitted to be slightly less efficient than the best real asbestos coverings, but then it is much cheaper.

Gas v. Electric Light in New York.—Statistics prove that the growth of gas consumption in New York City, for 40 years prior to the introduction of electricity for lighting purposes, averaged about 10 per cent. per annum. That is, the gas output doubled every 10 years, and that the city had doubled in population every 17 years. Since the first introduction of the electric light, however, the increase in New York of the consumption of gas had been much more rapid. It almost immediately jumped up to 12 per cent. per annum, and in 1887 showed a growth equal to about 14 per cent. per annum, a ratio of growth that was still further exceeded in the years 1888-89-90 The gas output of New York is doubling itself now in a period of six and one-half years, instead of 10 years as before. The President of the Standard Gas Company thinks that one reason for this very rapid increase is due to the fact that the electric light has educated the human eye "in the aggregate" for a demand for more light, and that people are not at all satisfied with the volume of light that formerly satisfied them.

The Reactions in the Aluminium Electrolytic Process.—The character of the reaction in the chief process by which pure aluminium is produced on a commercial scale in Europe and in this country, has, says Mr. Alfred H. Bucherer, in the *Engineering and Mining Journal*, been the subject of discussion among metallurgists and chemists, but often opinions have been passed on it which prove the lack of thorough study and of practical investigation. I have had opportunity to see this process worked for a long space of time, and have experimented largely with the great facilities offered by the plant of the Cowles Company and of the Pittsburg Reduction Company, and therefore think I may be able to throw some light on this interesting question. In my opinion the cycle of reactions by which aluminium is produced in the various electrolytic processes, in whatever form they may appear, is the following: The current acts on the aluminium fluoride, aluminium is deposited at the cathode and fluorine at the anode. The free fluorine at once exerts its affinity for the aluminium in the alumina, and with the help of carbon forms aluminium fluoride, and at the same time carbonic oxide is formed. The aluminium fluoride, in turn, is decomposed.

Glasgow.—The City Engineer has supplied the Electric Lighting Sub-Committee with particulars as to ground belong-

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ing to the Corporation and the Improvement Trustees. At the meeting of the Sub-Committee, held last week, a letter was read from Messrs. Fawcus and Cowan with reference to utilising the Falls of Clyde for generating electricity for the supply of the city. The Sub-Committee instructed the Town Clerk to state, in reply, that a proposal of the same nature was some time ago brought before the Town Council, but was not entertained by them. A communication was also read from Messrs. S. Z. de Ferranti with reference to adopting the high-tension alternating-current system for the lighting of the central and outlying areas of the city, instead of the low-tension continuous-current system. The Sub-Committee instructed the Town Clerk to intimate to Messrs. de Ferranti that the proposal contained in their letter could not be considered. The Sub-Committee afterwards resolved to recommend that a permanent electrical engineer should be appointed by the Town Council. At their meeting held this week, the Sub-Committee agreed to recommend that the salary to be offered to the electrical engineer should commence at £250 per annum.

The Fatigue of Metals.—With respect to statements that occasionally appear on the subject of the fatigue of metals under long-continued stress, a report that has recently been published regarding two similar suspension-bridge links is worthy of notice. A square iron link, 12in. wide, 1in. thick, and about 12ft. long, was taken from a bridge at Kieff, then about 40 years old, and tested against a similar link which had lain unused in store ever since the building of the bridge. The means of comparison were, therefore, excellent, and the result should go a long way to show whether or not iron really does lose any of its strength in prolonged service. The effect of the tests was to determine for the old used link an ultimate tensile strength of 21·8 tons per square inch, an elastic limit of 11·1 tons per square inch, an elongation of 14·05 per cent., and a contraction of 17·35 per cent. at the point of fracture. For the unused link, the tensile strength was found to be 22·2 tons per square inch, with an elastic limit of 11·9 tons, and elongation and contraction at fracture of 18·42 per cent. and 18·75 per cent. respectively. The two pieces of iron were, therefore, of practically identical strength; for the small difference actually observed is well within the ordinary range of variability of similar pieces of the same metal.

New Cross Technical and Recreative Institute.—This Institute will be opened by the Prince and Princess of Wales on the 22nd inst. Amongst the appointments already made are the following:—Head of Engineering Section: Mr. W. Lineham, M.I.M.E., late Professor of Engineering at the Newcastle-on-Tyne School of Science and Art. Assistant Instructor: Mr. H. Ashton, foreman in pattern-making department at the Brush Electric Light Company's workshops. Head of Chemistry Section: Mr. A. Bloxam, F.I.C., late Demonstrator of Chemistry, Royal Agricultural College, Cirencester. Mathematical Lecturer: Mr. J. Taylor, assistant lecturer at the City and Guilds Technical Institute. Lecturer (Electrical Section): Mr. W. Slingo, Principal of the Telegraphists' Central School of Science. Assistant: Mr. A. Brooker. The classes will begin on October 1st, and the Session will last about seven months. The following are some of the classes which will be ultimately formed:—Brass Finishing and Fitting; Chemistry (practice and theory); Engineering (practice and theory); Electrical Engineering (practice and theory); Mathematics; Magnetism; Machine Drawing and Construction; Mechanics (theoretical and applied); Metal Plate and Zinc Working; Metal Turning and Fitting; Metallurgy; Physics; Steam; Tanning; and Telegraphy.

Damage by Lightning.—During a thunderstorm which broke over the village of Montacute (Somerset), last week, a splendid cedar on St. Michael's Hill, conspicuous in the district for several miles round, was completely shattered. The tree was about 90ft. in height and about 14ft. in circumference at the base. The discharge, after shivering the top into several pieces, ran down the trunk, splitting it into two parts, nearly 50ft. in length. On Monday a thunderstorm broke over Buckingham. The lightning struck one high-pitched roof of the Congregational Church, and damaged both sides of it. Flames almost immediately shot up from the roof, but the fire brigade soon got the fire under. On Wednesday a thunderstorm broke over the northern portions of London. At Tottenham High Cross three houses were struck by the lightning and considerably damaged, one being set on fire. The Seven Sisters Hotel was also struck, and a large chimney stack and a considerable portion of the roof was demolished. At Edmonton a labourer, who was haymaking, took shelter under a tree, when he was struck by the lightning. The man's clothes were torn into ribbons. At Chicago, on Monday, during a heavy storm, the recently imported balloon in the grounds of the World's Fair was struck by lightning and destroyed. The aeronauts were severely injured.

The Five-Wire System in Paris.—With the exception of the Vienna and Königsberg stations, the 45,000 light station, supplying the Place Clichy sector, which was recently inaugurated, is the only one of its kind in Europe. The Paris station has three floors, and covers a superficial area of 19,800 square feet. In the basement is the boiler plant, which comprises six of the Naeyer multitubular type. The ground floor is occupied by the steam piping, while on the first floor are placed the engines, dynamos, and the distributing board. The generating plant comprises three 150 H.P. Armington and Sims engines, each belt driving two shunt-wound dynamos, and three 500 H.P. Corliss engines, running at 64 revolutions, and each of which is coupled direct to a 350 kilowatt (700 amperes × 500 volts) eight pole machine. The armatures of these dynamos are 11ft. in diameter, and the brushes bear on their exterior. A 250 cell battery of Laurent-Cely accumulators supplies current during the night. The district supplied by this station has an area of nearly two square miles, and the most distant feeding point is 2,750 yards away. To keep the pressure on the different branches at the proper value six sets of automatic apparatus are employed. The mains are all lead-covered, iron-armoured Siemens cables. Aron meters are employed, and are modified to suit the exigencies of five-wire distribution, that is to say, the coils are arranged so that the current in the two outer leads exerts double the magnetising influence of the current in the two adjacent leads, the central wire not passing through the meter at all. The Société Alsacienne de Constructions Mécaniques is responsible for the erection of the whole system.

Transmission of Power at Locle.—The following are some further particulars of the interesting little transmission of power plant at Locle, which was briefly alluded to in *The Electrician* of July 25, 1890. In December, 1887, the Communal authorities of this great Swiss watch-making district invited tenders for the erection of an electric light and power plant, and the plans of MM. Cuerrod et Sautter, of Geneva, were accepted. The specifications required the supply of 50 H.P. for eleven hours each day, and current sufficient for 2,500 10 c.p. lamps for five hours. The motive power was to be derived from the Bied, two miles distant, where a head of 300ft. and an average flow of 24½ gallons per second were available, and where a reservoir of 2¼ million gallons capacity was to be built. The contractors decided to adopt the three-wire system, and a difference of potential at Locle of 300 volts, 150 volt lamps being employed, the smaller motors being taken off the 150 volt leads, and the larger ones being connected across the external wires. Taking the minimum flow at 3 gallons per second, the effective head at 280ft., and the efficiency of the turbines at 75 per cent., some 1,750 H.P. hours are rendered available in 24 hours. Now, 50 H.P. for 11 hours, *plus* 2,500 3¼ watt lamps for five hours, demand some 1,200 H.P. hours; so that the daily allowable loss in the dynamos, line, and network is 550 H.P. hours, or 32 per cent. As a matter of fact, the loss in the line at full load amounts to 48 H.P. The plant comprises one 220 H.P. horizontal turbine, coupled direct to two 80 kilowatt Thury dynamos, one 30 H.P. turbine coupled direct to two 10 kilowatt machines, a reserve 80 kilowatt turbo-dynamo, and a 100 H.P. steam engine. Automatic speed regulators for the turbines, and automatic field resistance regulators for the dynamos, are employed. The largest size motor allowed is of 6 H.P. The prices charged vary according to the size of the motor and to the method of payment; thus, a one horse power can be had for £20 a year, or for 9d. an hour by meter. The price seems to us to be prohibitive, especially where labour is comparatively cheap.

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MAGNETISM IN IRON AND OTHER METALS.*—XLIV.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 182.*)

§ 154. **Equation of the Magnetic Circuit.**—Returning now to the case of a perfect magnetic circuit, we have to consider the connection of the magneto-motive force or line integral of magnetic force along the circuit and the magnetic flux. Suppose the circuit to be divided up into a number of tubes of induction, in any one of which the cross-section is small, so that **B** and **H** may be taken as uniform over any one cross section of the (small) tube. The relation which we establish for each small tube may easily be extended to apply to the whole magnetic circuit, which is built up of such small tubes placed side by side. Let s be the area of cross-section at any part of the small tube, and **B** the magnetic induction there. The flux in the tube is $\mathbf{B}s$. If μ be the permeability of the substance, the magnetic force **H** at the same place is $\frac{\mathbf{B}}{\mu}$; hence

$$\frac{\text{flux}}{\mu s} = \frac{\mathbf{B}}{\mu} = \mathbf{H}.$$

Multiply each side by an indefinitely short length of the tube dl—

$$\text{flux}\,\frac{dl}{\mu s} = \mathbf{H}\,dl.$$

Integrate both sides, remembering that the flux is constant at all sections;

$$\text{flux} \times \int\frac{dl}{\mu s} = \int \mathbf{H}\,dl = \text{magneto-motive force},$$

when the integration is extended round the whole circuit;

hence,
$$\text{flux} = \frac{\text{magneto-motive force}}{\int\frac{dl}{\mu s}}.$$

The meaning of the denominator may be most readily seen if we write ρ for $\frac{1}{\mu}$ and call ρ the *specific magnetic resistance* of the substance. Then $\frac{\rho\,dl}{s}$ is evidently the magnetic resistance of that portion of magnetic circuit which has the length dl and the cross section s. The idea of magnetic resistance is introduced here in a sense strictly analogous to the idea of electric resistance in the electric circuit. The specific magnetic resistance ρ is the analogue of the specific resistance to conduction—namely, the resistance of a piece of the conductor of unit length and unit areas of cross section. The quantity $\int\frac{\rho dl}{s}$ is simply the sum of the resistances of successive short portions of the length of the circuit. We may, therefore, write the equation of the perfect magnetic circuit thus,

$$\text{flux} = \frac{\text{magnetomotive force,}}{\text{magnetic resistance of the circuit,}}$$

which is the magnetic analogue of the familiar equation of conduction

$$\text{current} = \frac{\text{electromotive force}}{\text{conduction resistance of circuit.}}$$

There is, however, this reservation to be borne in mind in pursuing the analogy. In the conduction circuit the specific resistance of the material is not a function of the current, that is to say, its value is independent of the amount of the current. In the magnetic circuit ρ and μ are functions of the flux, for they depend on the value of **B**. More than that, they may have many possible values even when the value of **B** is assigned, for they depend not only on the existing magnetic induction, but on the previous magnetic history of the piece. But the equation of the magnetic circuit will be correct and intelligible if we define μ as nothing more or less than the value which the quotient $\frac{\mathbf{B}}{\mathbf{H}}$ happens to have at that place in the circuit to which reference is made, and if we define ρ as the reciprocal of that quantity, or $\frac{\mathbf{H}}{\mathbf{B}}$. We may have a magnetic circuit in which there is no magneto-motive force, but in which there is (residual) magnetic flux. In that case the "magnetic resistance" of the circuit must vanish, and the mean value of ρ must be zero. We may even have a magnetic circuit in which the direction of the flux is (on account of past magnetisation) opposite to the direction of the magneto-motive force, which implies a negative value of μ and of ρ.

In most of the cases to which the conception of the magnetic circuit may be usefully applied, the effects of previous magnetisations are absent or negligible, so that the values of μ which are to be used, are the permeabilities which are derived from the ordinary curve of magnetisation (for the particular material of the circuit), that is to say, from the curve which expresses the relation **B** to **H** when **H** is progressively increased from zero and the metal is free of magnetism to begin with.

In many instances the circuit may be treated as (very approximately) made up of a series of portions, in any one of which μ is constant and s is constant. Thus, calling l_1 the length of one of these portions, μ_1 its permeability, and s_1 its cross-sectional area, l_2 the length of the next, μ_2 its permeability, and s_2 its sectional area, and so on, we have

$$\text{flux} = \frac{\text{magnetomotive force}}{\frac{l_1}{\mu_1 s_1} + \frac{l_2}{\mu_2 s_2} + \frac{l_3}{\mu_3 s_3} + \&c.},$$

as many terms being taken in the denominator as are needed to complete the circuit.

And if the object is to express the value of the induction at any place in the circuit in terms of the magnetomotive force, we have only to divide the flux by the area of cross-section there. Thus, if it is wished to express $\mathbf{B}_1$, the induction in the first portion of the circuit, where the area of section is s_1, we have

$$\mathbf{B}_1 = \frac{\text{flux}}{s_1} = \frac{\text{magnetomotive force}}{\frac{l_1}{\mu_1} + \frac{l_2}{\mu_2}\cdot\frac{s_1}{s_2} + \frac{l_3}{\mu_3}\cdot\frac{s_1}{s_3} + \&c.},$$

Or, again, if what is wanted be to calculate the number of ampere turns which are required to produce a stated magnetic flux in a magnetic circuit made up of a series of portions of which the lengths, sections, and permeabilities are known, we may find the magnetomotive force from the formula

$$\text{Magnetomotive force} = \text{flux}\left(\frac{l_1}{\mu_1 s_1} + \frac{l_2}{\mu_2 s_2} + \frac{l_3}{\mu_3 s_3} + \&c.\right),$$

and then find the number of ampere turns by dividing their magnetomotive force by $0{\cdot}4\pi$. This is, in effect, the problem which is attacked in calculating the winding of the field-magnets of a dynamo. The problem is analogous to that of finding the electromotive force necessary to drive a stated current through a circuit composed of a series of conductors of which the specific resistance, the length, and the cross section, are assigned.

§ 155. **Particular Cases: Continuous Ring wound uniformly and otherwise.**—The utility of the idea of the magnetic circuit will be apparent when we consider one or two examples. Take first the case, already familiar, of a uniform ring uniformly wound with a magnetising coil of N turns. Let l be the length of the ring, measured round any circle within the ring parallel to the sides. The magnetic force at all points of such a circle is $\frac{4\pi\,\mathrm{C\,N}}{l}$, and the line integral of this, or the magnetomotive force, is $4\pi\,\mathrm{C\,N}$. If s be the area of cross section, the magnetic resistance of the ring is $\frac{l}{\mu s}$, and the flux, which is equal to the magnetomotive force divided by the resistance, is—

$$\frac{4\pi\,\mathrm{C\,N}}{\frac{l}{\mu s}}$$

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We might, of course, have derived this expression for the flux otherwise, namely:—

$$\text{Flux} = \mathbf{B}\, s = \mu\, \mathbf{H}\, s = \frac{4\pi\, C\, N\, \mu\, s}{l}.$$

The line-integral of magnetic force has the same value over all lines that thread through the magnetising coil. Moreover, the magnetic force **H** is itself constant at all points of the circle l, parallel to the sides of the ring; so that the line integral is $\mathbf{H}\, l$. To compare the values of **H** at different points in the substance of the ring, at distances r_1, r_2, &c., from the axis of the ring, we have $\mathbf{H}_1\, l_1 = \mathbf{H}_2\, l_2$, $l_1 = 2\pi r_1$, and $l_2 = 2\pi r_2$; hence, $\mathbf{H}_1\, r_1 = \mathbf{H}_2\, r_2$. In other words, the magnetic force, due to uniform winding on a uniform circular ring, varies across any section in inverse proportion to the distance of the point from the axis of the ring. (*See* § 57 above.)

In the case of a uniformly wound uniform ring there is no special advantage in applying the conception of the magnetic circuit. The results to which it leads are obtained, with no less ease, by considering the magnetisation and magnetic force at any individual point of the metal. But it should be noted that the conception of the magnetic circuit makes it possible to avoid any use of, or reference to, the quantity **H**. We have derived the notion of magnetomotive force from that of magnetic force, by taking the line integral of **H** round the magnetic circuit. But that is by no means a necessary order of ideas; nor is the notion of **H** indispensable in the treatment of the subject. The magnetomotive force may be defined without reference to it, and the flux may be stated in terms of the magnetomotive force and magnetic resistance, so that all use of **H** may be excluded. It is even theoretically possible to treat all cases of magnetisation in the same way:—with a magnetised bar, for instance, the magnetic circuit is completed through the surrounding non-magnetic medium, and a sufficiently powerful analysis might determine the resistance of the circuit, and so allow the relation of magnetic flux to magnetomotive force to be treated without any allusion to the magnetic force at individual points of the bar. But to apply this method universally, though theoretically possible, is quite impracticable; and there are very many problems in regard to which the older modes of viewing the subject, described in earlier articles of this series, are infinitely more convenient. The student must not think to abandon the consideration of magnetic force and magnetisation at individual points because he finds that the notion of the magnetic circuit is remarkably useful in certain cases, and has, in theory, no limits to its application. Its real value lies in the fact that by the help of it problems which would otherwise be intractable may be solved with sufficient exactness for practical purposes. To trace, for example, from point to point in the core of a transformer or the field magnets of a dynamo the value of **H**, and so determine the magnetisation, would be a task the difficulty of which would be prohibitive. But by applying to such cases the method of the magnetic circuit, a solution is readily arrived at—not, indeed, a rigorous solution, but one that satisfies the requirements of the electrical engineer.

In the case dealt with above—that of a uniform ring uniformly wound—the metal of the ring forms a perfect magnetic circuit. None of the lines of induction stray into surrounding space; the ring itself is a tube of induction, and the flux is constant at all cross sections.

Suppose, however, that, instead of being uniformly wound, part of the ring, Q, is bare and the magnetising coil is heaped up on the other part P (Fig. 131). In that case the flux through P is greater than the flux through Q, for some of the lines of induction which thread through the coil close themselves by passing not through the bare part of the ring but through surrounding space in the manner indicated by the dotted lines. The ring is now an *imperfect* magnetic circuit. If, however, the material is very permeable, like soft wrought iron (the magnetic permeability of which, when not too strongly magnetised, is some two or three thousand times as great as permeability of air), and if the ring is short, this leakage of lines of induction into surrounding space will take place to only a very limited extent; by far the greater number of the lines through P will complete their circuit within the substance of the ring, and the flux at Q will be only a very little less than the flux at P. We may, therefore, in such a case, as a first approximation, treat the flux in the ring as constant, and apply the equation of the perfect magnetic circuit, flux $= \frac{4\pi C N \mu s}{l}$, to find it. This quantity is, in fact, slightly less than the flux in the part P, because the resistance of the actual magnetic circuit is a trifle less than that of the ring, through the "shunting" of a part of the ring by the surrounding air. On the other hand, the flux, as calculated above, is greater than the true flux at Q.

The case is analogous to that of a conducting circuit, which instead of being perfectly insulated is immersed in a poorly conducting fluid. Imagine a ring of copper with a seat of electromotive force at P to be immersed in a liquid, the conductivity of which is only one two-thousandth or one three-thousandth that of the copper. The current at Q will be only a little less than the current at P; the current which leaks into the surrounding fluid will be an inconsiderable part of the whole. We must repeat the proviso that the ring is short; in other words, that the surface through which leakage occurs is not very great in comparison with the area of cross section through which what we may call legitimate conduction occurs.

The advantage of regarding the iron ring as a magnetic circuit, nearly, though not quite, perfect, is at once apparent when one considers how difficult it would be to determine directly the

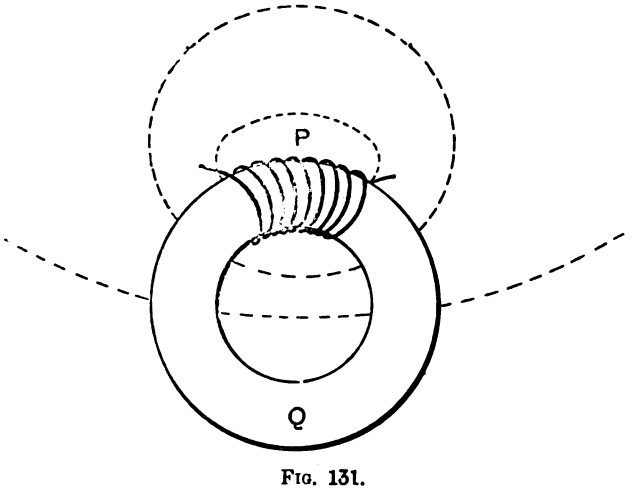

Fig. 131.

magnetic force **H** at individual points. In the case of a uniformly wound ring there was no difficulty in determining **H**, because it was wholly due to the magnetising coil. In the present case **H** is by no means due to the coil only. The coil acting alone would produce a strong magnetic force at points within and close to it, and would produce very little magnetic force in more distant portions of the ring. But we know that **H** must actually be pretty nearly uniform throughout the ring, because the magnetisation is pretty nearly uniform. What tends to equalise **H** is the free magnetism in the ring itself—the free magnetism which exists in consequence of the very fact that the flux is not quite uniform.

The magnetic force at any point is due partly to the action of the free magnetism and partly to the action of the coil; at points within and near the coil the free magnetism diminishes **H** by opposing the action of the coil, but augments **H** at points on the bare side of the ring. It is just because the ring is not a perfect magnetic circuit—because there is some leakage of the flux into surrounding space—that the magnetic force (and, therefore, the induction) is fairly uniform all round. In a short ring of very permeable substance, a slight variation in the flux from point to point of the ring will imply enough free magnetism to correct very nearly that excessive inequality in the magnetic force which is produced by the magnetising coil; in other words, the circuit then establishes itself with but little leakage.

(To be continued.)

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CAPACITY TESTS.

BY ARTHUR DEARLOVE.

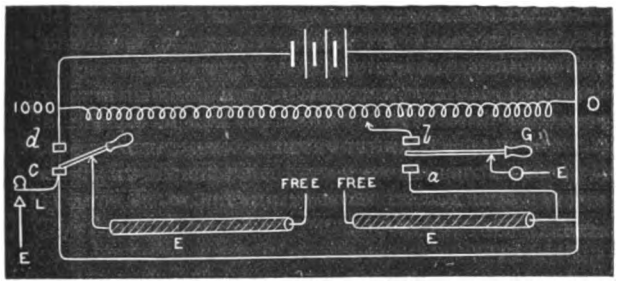
The following modification of "Gott's Test" for comparing or determining the capacity of Cables was suggested to me by Mr. Herbert Taylor. I have tried the test and obtained satisfactory results.

For the comparison of condensers or for finding the capacity of a cable when a condenser is used as a standard the test has no advantages over the Gott's method, but the value of the suggestion consists in the fact that with duplicate cables the position of a ruptured conductor or their relative capacity is quickly and accurately found.

The test is practically an "electrostatic loop test," and the following diagram shows the plan of connections; it is, perhaps, a little more complicated than the original method, but will be easily understood by those familiar with "Gott's Test," and with the method of finding the correction for absorption and eakage suggested by Dr. Muirhead.

It is essential in this test that both the battery and slides should be very carefully insulated, or wrong values will be observed. The correction for difference of absorption or leakage can be observed in much the same manner as described in *The Electrician* of March 6, 1891.

Having joined up, as shown, proceed as follows: First to make certain that the cables are thoroughly free of charge depress the key L, putting both cables to earth for a few seconds, then charge both cables by putting down key K, obtain balance at the end of any given number of seconds by trial and error, moving the index of slides until depressing key G gives no deflection.



In practice, I have found it most convenient to charge the cable for, say, five seconds, then instantaneously put galvanometer on to index of slides; if balance is not obtained, raise key K and depress key L before charging again—repeat the operation of charging until balance is found.

If there is no difference of absorption or of insulation resistance in the cables compared, no correction is necessary, and the observed standard resistance gives the correct ratio between the capacity of the two cables, so that knowing the capacity of either the capacity of the other is found.

Should there be a large difference in absorption, or should one cable be of low insulation, the correction desired is obtained in the following way:—

The condition of things being as in diagram, and the cables free of charge, charge them from the battery, as before, and at the end of, say, five seconds, put both ends of the cable together by key K; allow them to remain so, for, say, a period of three seconds, then discharge the cable through galvanometer to earth by raising key G, and note the deflection, say, *d*.

To obtain the value in slide readings of this deflection, the index of the slides is run back towards the end of slides marked O, and key G is depressed, placing galvanometer on to index, moving the index until the same deflection is produced—the standard resistance so observed is the correction, and is additive to the initial standard resistance at balance if in the same direction as throw *d*, subtractive if in the opposite direction.

Between each operation the key L should be put down for a few seconds to discharge the cables.

The two cables actually compared were coiled cables, one length on board ship and the other in the factory tank; their respective lengths were 360 and 255·5 knots.

No correction was observed, as the cables under comparison were of the same material and insulation resistance.

To imitate a cable with faulty insulation a leak of 1 meghon and in another instance of half a megohm, was put in on one section and the correction observed.

The results are given below:—

	Mfds.	Mfds.	Knots.
360 knots (capacity determined with standard condenser	30·76	= 131·57)	*versus* 2
Capacity at 75° in 2 knot lengths		= 130·59	

Ch. 5"	Bal. S.R.	Ratio of S.R.	Ratio of Cap. 75° value.	Ratio o length.
	5,864 no correction...	1·418	... 1·413	1·409

The capacity of the 255·5 knots, taking the 360 knots a s standard (131·5 mfds.) = 92·80 mfds., the capacity of the section being 92·53 by the tests at 75°

360 knots was then put to earth through one megohm.

Ch. in secs.	S.R. at bal.	Mixing period. secs.	Correction discharge.	Value in S. R.	Corrected S. R.	
5 ...	5,963 ...	3 ...	180 Z − ...	95 = 180 R ...	5,868	Slide reading taken as correct 5,864 as above.
½ megohm leak						
5 ...	6,059 ...	„ ...	80 Z − ...	187 = ...	5,872	

The corrected slide reading in both cases where leaks were inserted, agrees closely with the first standard resistance obtained at balance when both cables were under normal conditions, and gives the actual capacity of the section within small limits of error.

The test is applicable in many directions, which will suggest themselves to those interested in the question; for instance, two cables being compared frequently for a given time of charge, the slide reading at balance should always be constant; if a different standard resistance is observed at any time it may be inferred that the insulation of one or the other has probably altered.

This test is also a loss of charge test, and the correction found when both cables are of the same material is practically a measure of their respective insulation resistances.

Some time since attention was drawn to the value of the correction suggested, and I give the following figures obtained recently under the method now described in support of the opinion expressed in *The Electrician* of March 6 last.

Standard Condenser 30·763 mfds. versus 360 kts. cable.

Ch. secs.	S.R. at bal.	Mixing period secs.	Correction discharge in divs.	Equivalent in S.R.	Corrected S.R.	Capacity per kt.
5 ...	1,935 ...	3 ...	45 r ...	− 38 ...	1,897	Mean corrected slide reading 1.895 = 131·57 mfds. = 0·366 mfds. per kt.
10 ...	1,974 ...	3 ...	100 r ...	− 74 ...	1,900	
15 ...	1,993 ...	3 ...	51 ...	− 100 ...	1,893	
20 ...	2,035 ...	3 ...	70 ...	− 144 ...	1,891	
25 ...	2,059 ...	3 ...	82 ...	− 166 ...	1,893	
30 ...	2,084 ...	3 ...	102 ...	− 187 ...	1,897	

It is obvious that had the correction not been applied, a largely different value for the capacity of this section of 360 knots for each time of charge would have been accepted.

I may point out that no correction for leakage is found when the insulation resistance per microfarad is the same in the standard condenser and in the cable compared, but the correction becomes necessary when large differences of absorption exist between the two capacities under test.

Royal Institution.—At the general monthly meeting of this Institution, on Monday last, the special thanks of the members were returned to Miss Jane Barnard, Dr. J. H. Gladstone, the Rev. A. R. Abbott, Mr. T. F. Deacon, Mr. A. Blaikley, and others, for the loan of the valuable and interesting collection of Faraday memorials shown in the library on the occasion of the two lectures, on June 17th and 26th, given in commemoration of the Faraday Centenary. The special thanks of the members were also returned to Mr. Ludwig Mond for his donation of £100 towards expenses connected with the Faraday Centenary commemoration.

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A CONTRIBUTION TO THE STUDY OF ATMOSPHERIC ELECTRICITY.*

BY C. ANDRÉ.

It is generally supposed that there is in the case of atmospheric electricity a normal diurnal variation, corresponding to calm weather and a clear sky. An investigation of the observations taken at Lyons since the year 1884, by means of the recording electrometer of M. Mascart, does not confirm this view of things. In fact, let us pick out from among the clear, calm, cloudless† days those on which the prevailing wind blows from the North or from the South (this is to say, nearly all), and let us determine the average daily variation in each of these cases for the spring, summer, and autumn. We obtain curves similar to those shown in Fig. 1, which bring to light a diurnal variation which is very different in the two cases, the amplitude of the day oscillation being three times as great as that of the nocturnal oscillation for a southerly wind, whilst for a northerly wind, on the other hand, it is the nocturnal oscillation which is treble that of the day. The addition to these calm days of fine days on which the wind blows more or less strongly (Fig. 2) does not change the general character of the daily variation, the characteristic differences which I have just pointed out persisting within sensibly the same limits. The so-called *normal* daily electrical variation is, therefore, the combination of two different states, corresponding, moreover, to two different distributions of pressure relative to the place of observation.

This conclusion is not limited to electric potential; the same method of separating out applied for the same days to barometric pressure, and to weight of water vapour contained in a given volume of air, bring to light for these two meteorological elements also two different daily variations. The phenomenon is especially striking in the case of weight of water vapour (Fig. 3), the daily variations of which are sensibly parallel to those of electric potential. In the same way the annual variations of relative humidity and electric potential are so very similar that their curves (Figs 4 and 5) seem to be traced from each other.

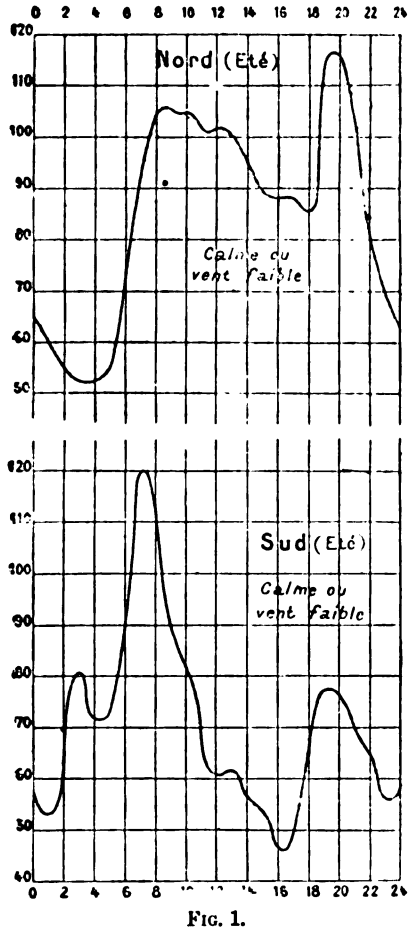

FIG. 1.

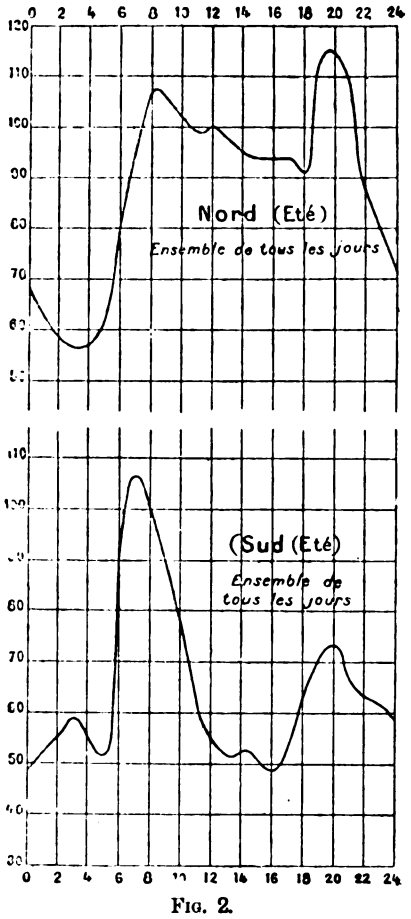

FIG. 2.

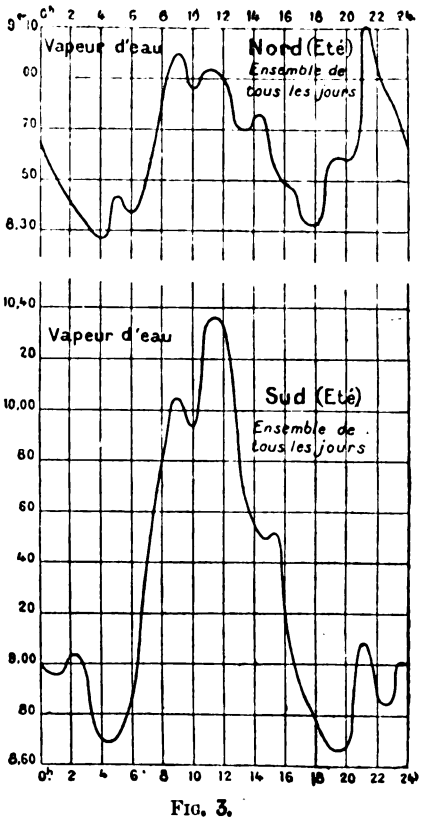

FIG. 3.

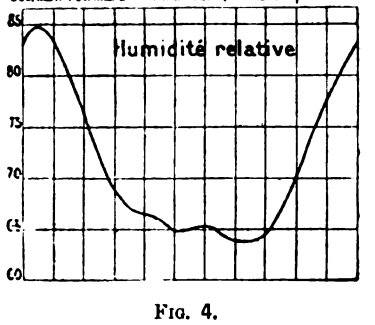

FIG. 4.

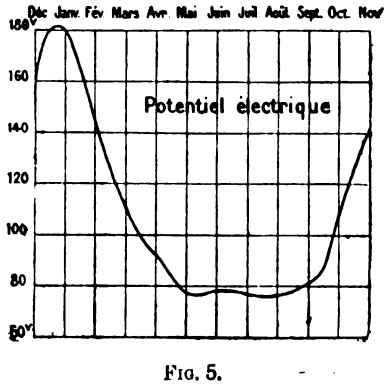

FIG. 5.

Such are the principal facts brought to light at the Lyons Observatory. They seem to imply the existence of a close connection between the variations (and their causes) in the case of the three above-mentioned physical phenomena. It would be very interesting to know if the investigation of the observations made at the other French electrical observatories lead to similar results.

* *Comptes Rendus*, Vol. CXII., No. 26.

† For us the weather is calm and the sky clear—(1) if the speed of the wind exceeds at no instant during the day 2·5 metres per second, (calm or gentle breeze); (2) if out of the 13 daily observations of nebulosity, one at least gives a value equal to ·1.

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THE TRANSFER OF ENERGY.

The discussion between Mr. SPRAGUE and Prof. THOMPSON, as to the way in which energy is conveyed by the agency of electric currents, has now come to a close, and our readers have had the opportunity of comparing the different arguments which have been advanced. We could hardly have found two more fitting champions for maintaining the rival views which these two writers have upheld, but from the nature of the case Mr. SPRAGUE has been at a great disadvantage. Prof. THOMPSON has, with admirable skill, put into a simple form an already recognised theory, the latest development of ideas which have absorbed the attention of the ablest electricians for years; but Mr. SPRAGUE has had to generate all his arguments for himself, starting from the hypothesis that the energy of an electric current is conveyed along the conductor. The theory that the energy is conveyed along the wire has the merit of simplicity. It has been tacitly accepted by the great majority of electricians ever since it has been known that the electric current is a factor of energy, and many of our readers have, to our own knowledge, been greatly interested in Mr. SPRAGUE's defence of this view against what must be owned to be a complicated theory. We may agree with Mr. SPRAGUE that our object should be "to find out what Nature does, not to invent mere imaginary schemes about her works," and, although we undoubtedly side with Prof. THOMPSON's views, there is no doubt much which appears, at first sight, highly artificial in the elaborate structure of lines of electric and magnetic force and induction, complicated still further, as it is, by the more recently

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discovered lines of energy-flow. But however desirable it may be to simplify our conceptions of natural processes, we cannot expect to do so all at once. The aim of science is not to find out what is simple, but what is true. The electro-magnetic theory is certainly not simple, but it has much to recommend it; while the idea that energy is conveyed along wires really had its origin, not in any definite theory, but in the fact that the wire was the only tangible thing about an electric current, and the energy was assumed to be connected with it simply because there was nothing else with which it could be associated.

Mr. SPRAGUE has supported an old idea rather than an old theory. The orthodox views advocated by Prof. THOMPSON are of comparatively recent date, but up to the present they form the only theory which has ever been advanced to account for the facts; for, although the notion that the current conveys the energy is very generally entertained, Mr. SPRAGUE is, we believe, the first to support it by argument. Indeed, the idea that energy is located at all, and that, when it changes its position, it must move along a definite path, is quite a new one. The law of the conservation of energy implies that energy cannot disappear from one place without appearing in equal quantity somewhere else; but, although this fact has been long accepted, it is only within the last few years that the idea of the transference of energy has been developed, or that anyone has attempted to trace out the actual path along which energy flows when it moves from place to place. The idea of an energy current is of more recent date than the electro-magnetic theory, and is not to be found explicitly stated anywhere in MAXWELL'S work. We believe that the first time it was applied to electrical theory was in the pages of *The Electrician*, by Mr. OLIVER HEAVISIDE, to whom so much of the extension of MAXWELL'S theory is due. The idea was also independently developed and brought to the notice of the Royal Society in a Paper by Prof. POYNTING. According to the theory, as developed by these mathematicians, the paths along which the energy flows are sometimes of a very remarkable character, but they are not more so than is the case with the well-known and widely understood lines of force generated by the magnetic action of the current, and there is no reason for supposing that the energy paths should be simpler than these. The view that the energy flows with the current is only simple in appearance. Energy does not flow like an electric current round the circuit continuously, for it flows from the generator to the motor, or other absorber, and does not return. If it is confined to the wire it has a choice of paths before it, one with the current and the other against it, and Mr. SPRAGUE gives no reason for its adopting one path in preference to the other, but assumes that it may choose both. Even supposing that Mr. SPRAGUE'S views are tenable, the explanations he has given of the mode in which energy is conveyed are at least as complex as those of the electro-magnetic theory.

The chief obstacle to be overcome by the orthodox theory of to-day before it gains general acceptance is the difficulty people have in believing that large forces can be transmitted without the aid of rigid material connections. Mr. SPRAGUE expresses this view when he asks, "Does any one in his senses argue that, when a mechanical motor transmits energy by means of shafting or belts, the energy is really transmitted by some imaginary medium, and that the shaft and the belt are merely waste-pipes to get rid of some hypothetically superfluous energy which chokes the medium?" This question must be answered in the negative, but the case here considered is very unlike the transmission of energy from a dynamo by means of a pair of leads, although Mr. SPRAGUE appears to consider them identical. Supposing the dynamo to give an electromotive force of several thousand volts, many horse-power could be transmitted great distances by means of wires so thin as to be hardly visible. In such a case we could hardly imagine that anyone would suppose the energy is transmitted along the wire.

When the currents are alternating it is impossible to explain the transfer of energy from a primary to a secondary coil, except on one of two hypotheses. Either the energy must travel across the intervening space, or, by a sort of process of action at a distance, it must be capable of disappearing from one circuit and reappearing at the same instant in the other. Mr. SPRAGUE does not advance the latter hypothesis, and he virtually admits that energy can exist in the medium when, in explaining the diagram given on page 608 of the last volume of *The Electrician*, he alludes to the lines *e e* as representing "energy stored in producing stresses, chiefly *outside* the conductor." It is true that he does not say where the energy is stored, but it can only be logically located in the places where the stresses occur. The amount of energy thus stored, and the flow of energy in the medium necessary to supply it, becomes a very large fraction of the whole energy when alternate currents and transformers are in question; and it is of no use to leave out the consideration of such currents because, as Mr. SPRAGUE urges, steady currents are the simplest to consider. If it is once admitted that a large fraction of the energy corresponding with an alternating current is located in the medium, Mr. SPRAGUE'S contention must be abandoned.

Much of the obscurity of the subject arises from the difficulty of understanding the true function of the conducting circuit. To say that the wire acts merely as a guide to direct the flow of energy in the medium, and that the heating which occurs is only the waste energy caused by the method of constraint, does not make the matter, already rather complicated, any easier to understand. Ohm's law and the laws of electrolysis are so simple that it seems a retrograde movement to abandon the idea that an actual flow takes place in the wire, and, if the actions going on in the medium are so important, it is not easy to see, for instance, why the resistance of a parallel combination of conductors is not altered by bending the wires, or separating them. The hydraulic analogy, when closely examined, is, however, continually at fault, and Mr. SPRAGUE himself is dissatisfied with it, since he voluntarily abandons the words resistance and current, and proposes to substitute ohmage and amperage for them. We generally look upon the current in a solenoid as the *cause* of the magnetic force it exerts, but this idea has really nothing to support it. The fact that the strength of a current is a factor of its energy is no more a proof that the energy is held in the wire, than the indications of a pressure gauge on a boiler show that the energy of the steam is similarly located. A current is defined and is nearly always measured by the magnetic force found *outside* the wire. With the single exception of the heating effect, a current in a wire can only be detected by its external effects, and it is just as correct to argue that the magnetic condition of the medium should be regarded as the *cause* of the current as its *effect*. The path of the current is quite clear when we have simple circuits of good conducting material, but with imperfect insulation the course of the electricity may be far more complex than the supposed path of the energy current; and, indeed, cases exist in which the flow of energy takes place in a very simple manner indeed. When electrical energy is conveyed by a current through concentric mains, theory shows that the flow of energy is confined to the insulating material between the inner and outer conducting tubes, and that it passes from the

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source of energy to where the work has to be done. Here the path of the energy current is very simple, and the hydraulic analogy can be applied to it with even greater truth than to the flow of current in the tubes. The heating of the metal conductors is due to a kind of frictional waste occurring at the inner and outer surfaces confining the energy current, just as the frictional resistance to the flow of water in a pipe is due to surface action.

Until the electro-magnetic theory is further advanced it is unlikely that a discussion, such as Mr. SPRAGUE and Prof. THOMPSON have carried on, will alter the views of anyone already strongly biased upon the points at issue. The most valuable result of such a controversy is due to the fact that the opposing views are brought out with greater clearness than before. Prof. THOMPSON has freely admitted that there is no experimental evidence in favour of the orthodox theory when the currents flowing are steady, while, on the other hand, Mr. SPRAGUE has made it clear that he does not contend that the energy current is entirely confined to the wire, for he admits that the energy traverses the medium between the primary and secondary circuits of an induction coil. The theory explained by Prof. THOMPSON, however complex it may be, accounts exactly for the phenomena referred to, while the apparent simplicity of Mr. SPRAGUE'S views is mainly due to their purely descriptive nature. Prof. THOMPSON has gracefully allowed his opponent the last word in the controversy, and, in view of the fact that Mr. SPRAGUE excludes alternate current phenomena from argument, it is clear that further discussion can serve no useful purpose.

REVIEWS.

A Manual of Electro-Therapeutics. By ARTHUR HARRIES, M.D., and H. NEWMAN LAWRENCE, M.I.E.E. No. III.—The *Nursing Record* Series. (London: Sampson Low.) 1891.

We have always strongly sympathised with the genuine effort which the present authors have made to place "electro-therapeutics" on so sound a basis that it might rank as a department of medical science. They have most conscientiously placed themselves under a restriction which must occasionally hinder their practice, by making it a rule that they will only treat patients under independent medical advice. They have been most assiduous in the direction of the Institute of Medical Electricity, as well as in the production of numerous papers and handbooks, and considerable success has, we believe, attended their efforts. In carefully avoiding everything that can, by the most careless observer, be confounded with the shameless quacks who drive such a good trade in so-called electropathic appliances, the authors of the book before us have endeavoured to explain "in an easily assimilable form" the elementary facts of electrical science, and "the physiological and pathological phenomena which depend for their production upon the application of various forms of electricity, and the methods by which it has hitherto been possible to employ this agent in the treatment of pathological conditions." After a first chapter or "lesson" on electrical energy, different kinds of batteries are discussed, but we are surprised to find no mention whatever of the excellent "dry cells" which are now on the market, and which we should have thought were admirably adapted for the occasional work required for medical purposes. The next lesson—on electromotive force, current, and resistance—is greatly indebted to the hydraulic analogy, which, with no disrespect to the "nurses and students," to whom the handbook is addressed, is no doubt better suited for them than the more intricate hypotheses which have recently been argued in our columns. This chapter is marred by one sentence introducing an expression which somewhat disfigures the rest of the book:—"The quantity of electricity flowing through or past any point in a conductor during any given time is designated the current strength, or, more shortly, 'the current.' As however, we desire to avoid all risk of confusion regarding the terms involved, we prefer to call this factor in the current flow *current-strength*." The authors go on to use the signs C-s and c-s throughout the remaining chapters where they simply mean current in amperes or milliamperes. It is difficult to understand why some writers feel that the mere word current is ambiguous, and attempt to make things clearer by speaking of the intensity of a current or current-strength. Quoting at random from later pages we have, "a c-s of 15 milliamperes has to be administered," "cells in parallel give the maximum c-s," "an E.M.F. of seven volts, and C-s of 500 m.a. passed." By m.a. the authors mean milliamperes. We fail to see why this expression "current-strength" should be required in discussing electro-therapeutics, when engineers and electricians generally can get on with the single word "current," and with a simple symbol to represent it. We admit that current has two properties, strength and direction, and that it is sometimes convenient to speak of the strength of a current, but if the strength of a current is said to be greater at one time than at another, it simply means that the current is greater. We object to this expression, because it suggests that a current has an existence apart from its strength. The authors, in giving a short glossary at the end of this chapter, revert to exact and simple language viz., "Current. The quantity of electricity flowing through or past any point in a conductor during any given time." We have dwelt on this tautology at some length, not because it is uncommon, but for the very opposite reason.

The fourth "lesson" proceeds to consider some of the medical applications, and, as examples of the properties of continuous currents, they discuss Cataphoresis, Electrolysis, and Catalysis. We have accepted the first of these expressions, and have from time to time used the title "cataphoric medication" for several Notes on the subject. The authors' views are by no means accepted among physiologists, and we have not noticed that they point out that osmosis does not follow the same laws in the living tissue as in the dead. On the other hand, the authors have done much to establish this as a useful method of conveying drugs through the skin. Of electrolysis we need say nothing, but the treatment of catalysis as a distinct class of phenomena is rather strange. We have always considered catalysis as a permissive or directive action by which the presence of a substance determines a chemical combination, apparently by its mere presence, and with little or no expenditure of energy. It has, perhaps, become a convenient resting place for a residuum of unclassified phenomena, and in organic chemistry and biology, catalysis is used as a mere name for the action of ferments. But the authors include by it "both cataphoresis and electrolysis;" "dilatation of blood vessels;" "increased power of absorption conferred upon the tissues;" "promotion of osmosis, and following upon these two processes, increase of tissue bulk." A most comprehensive class, but one which is so wide as to be utterly vague and useless, and not warranted by the reasons assigned.

We have so greatly exceeded our usual limits that we must pass briefly over the latter chapters. The induction coil and magneto machines are alluded to, and the importance of measuring the "dosage of electricity" is very properly insisted upon. Various kinds of electrodes and other instruments are described, and a chapter is devoted to the physiological action of currents, but no allusion is made to the accepted phenomena of electrotonus. A chapter on skin resistance, a matter of some importance, since it determines the "dosage," ends with a table of observed resistances, but these varying from 620 ohms to 2,170, with no relation between the resistance and the path of the current, convey no information to the student, who may discover by computation that 1,200 ohms is the average, but as the conditions of "soakage" and contact are not given, this teaches him nothing. The tenth lesson deals very usefully with methods of application, and is followed by a number of practical hints about electrical applications and the management of apparatus.

The aim of the handbook is excellent, much of the matter is very useful, and the subject is one which we greatly desire

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to see developed. For these reasons we have dealt with it at some length, and hope that it will be carefully revised or will form the nucleus for the first comprehensive work on the subject, and one which may dispel the scepticism of the medical profession. The manual contains numerous illustrations. We can only suppose that the authors intended them to be re-drawn, and by some blunder their sketches were reproduced in fac-simile.

A First Course in Machine Drawing (Tracing). Part II. (Electrical Engineering). By GEO. HALLIDAY, Instructor of Mechanical Drawing and Lecturer on Mechanism at the City and Guilds of London Technical College, Finsbury. (London: E. and F. N. Spon). 1891.

Tracing is altogether ignored by many drawing masters, who endeavour to teach their pupils, at once, to make a drawing, as this is considered to be the ultimate object of a draughtsman. Such drawing masters have in many cases never set foot in an engineer's drawing office, and disregard the course of training usually followed by the engineer's draughtsman. The idea of beginning with tracing is as thoroughly practical as are the conditions of examination at Finsbury, to which we alluded last week. As a rule, the draughtsman begins to trace when a lad, and continues to trace, often for year after year, without ever a chance of trying pencil or pen upon drawing paper. While thus engaged, the subjects of his work, the conventions by which it is expressed, the style, and more than this, some intuition of the elements of design, cannot but sink into his mind. Besides this, he learns to do properly various matters which are essential to good drawing, *e.g.*, mixing inks, making good joins and even lines. It is obvious that after learning the mere mechanical work of tracing, the student will be much less likely to ruin his first drawing in the inking in.

The conventional rules of mechanical drawing vary very largely in different drawing offices, and we are not sure whether it is advisable to teach students that there is only one correct style. The only detail that we need refer to here is the uniform thickness of line which is insisted on as being of primary importance. Where greater clearness can be obtained by the occasional use of a thick line, either *as* a line or as a shade line, we do not think that any considerations of convention should forbid it, even in a tracing.

Dynamo Construction. A Practical Handbook for the Use of Engineer-Constructors and Electricians-in-Charge. By JOHN URQUHART. (London: Crosby Lockwood and Son. 1891.)

This book is a companion to the works by the same author on Electric Light and Electric Light Fittings. He offers it to "ordinary engineers and mechanics," and to "engineering students." If by "ordinary" engineers the author does not include electrical engineers, we think that he attempts too much. The history and development might be entirely omitted, just as modern text-books on steam-engine construction omit descriptions of the work of Newcomen and Stephenson. Of course, a book for beginners should begin at the beginning; but this beginning need not be of an historical kind. We are inclined to doubt whether it is necessary to go back to the "simplest conception of a dynamo." That is a matter of elementary electrical science. Twelve or fifteen years ago, it was still customary for pupils to go straight from school or college to the workshop, and there they learned the construction of steam-engines in the shops while they gradually picked up a knowledge of thermodynamics from text-books. Now it is more usual to learn the elements of physics and of the theory of the steam-engine at a technical college before apprenticeship. At all events, the study of electrical science and of dynamo construction are two totally distinct matters, and we should prefer to let the latter follow the former. An elementary account of the principles of the dynamo, such as the one before us, may be useful to "ordinary engineers" who have no intention of devoting much time to the subject. But as a text-book for "engineering students," the present work is insufficient. Far too many "typical dynamos" are described, and many of those which are included under this title are neither typical nor sufficiently worthy of notice. The causes of sparking, which should be clearly understood by all those who have to do with dynamos, are not clearly expressed, and among some otherwise useful "operative notes," it is suggested that "in starting a dynamo the brushes should be set in the most advantageous position. This will generally coincide with the line of least sparking." What the benefits may be of the "most advantageous position" which can compare with the importance of "least sparking" we are unable to guess. The Westinghouse and Ferranti dynamos are well described and many of the illustrations are new.

ELECTRIC AND MAGNETIC THEORIES.

BY JOHN T. SPRAGUE.

Prof. Silvanus P. Thompson in his last reply commences by admitting that there is no evidence, during the steady flow of currents, that energy is transferred across the medium; but he goes on to say neither is there any evidence that it is transferred along the wire. Now, that I must dispute. We have abundant evidence. We have the current, which needs energy to support it, and which is clearly originated in the source, being related to the chemical action when that source is a battery; we have the energy issuing from the wire, and if the circuit does no external work, we can trace the whole energy of the source present as heat in the conductor. When known actions occur in the medium, the current and energy in the circuit are proportionally diminished. Now, that is evidence, it is fact; the energy is in the wire.

But now examine the medium. I am blamed for refusing the evidence of the Hertz experiments. I have not done so. I only refused to bring confusion into this argument by dealing with very complicated actions, which no one even pretends to fully understand, while there was plenty of clear evidence available. But now I am going to claim that the Hertz experiments prove nothing of what it is asserted they do, and that, so far as they go, they prove my case. Prof. Thompson foresees my point: it is that the Hertz experiments, like all others upon induction, relate only to the variable period. The evidence that they give as to constant current is, that the medium, the space is wholly indifferent, that by no means can we trace the least action in space, except when current is varying in the conductor. Now, surely I may make the same claim as Prof. Thompson began by; I may say, if it is clear that energy is *not* transmitted across the medium during the full action of the source, then we have the right to say it is *not* transmitted from the source at any time.

§ 2. And that is what I do say, and consider that I have proved, and Prof. Thompson has done his best to prove for me, viz., that energy does not traverse space from the source "radiant in precisely the same sense as light is radiant," but that it is propagated only from the conductor by medium of the lines of electric and magnetic induction, set up only by the current in the conductor. As to this, he says, "unfortunately, it can be shown that it moves at right angles to them." That is a mere assertion which I defy him to prove. It is known that an action occurs at right angles, and that energy is propagated there; but what is the order of sequence? We all know that electric and magnetic action are interlinked, that one cannot be set up without the other accompanying it, to a degree dependent upon the nature of the matter present. When the magnetic lines are forming in his Fig. 1 of the two coils, the production of an electric field in planes at right angles to them is an inevitable incident; because his secondary coil occupies those planes, a momentary electric current is the inevitable accompaniment of the setting up of the magnetic lines and field But that is not lateral transfer of energy, even from the primary conductor; it is a lateral action of the newly forming magnetic lines, and the energy "swirls round" as required by the position of the conductors and the various lines of force.

But all these lines can be put in evidence; their stresses can be made visible. If the hypothetical lines cannot be so shown, I take it that the reason is the same as that which prevented the Spanish fleet from being visible in the old opera. I wholly decline to accept Prof. Thompson's assertion that "the energy paths in the medium are, after all, just as real entities as the

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magnetic lines are, though not so familiar to us." No one has the right to make such a statement without some evidence.

§ 3. I have no doubt that Mr. Heaviside is correct as to the result of this line of persistent assertion by the teaching powers. There can be no doubt that the growing generation of students will accept as truth the mere guesses of their teachers determinately asserted as proved truths; then they will go "by faith, having taken it when young. So it will be with the modern view of the ether as the medium through which energy is being sent when a wire supports a current. Only train up the young to believe this, and they will afterwards look upon the notion of its going through the wire as perfectly absurd, and will wonder how anyone could have believed it." Doubtless, they will believe it just as for a long period the scientific men believed in Phlogiston, and then some day they will learn that what they thought was knowledge was nothing but a delusion. That is what I am trying to prevent when I demand evidence of these assertions.

§ 4. Now let us examine for a moment the assertion that "electric energy is radiant in precisely the same sense that light is radiant." Now light is radiant in the sense that it issues as *radii* from a centre. Will Prof. Thompson, or anyone, show us one single instance of electric energy doing this. We all know that in the apparently similar case of a charged sphere, the seemingly radial lines exist only if a uniform opposed surface surrounds the sphere; if we bring that second surface into a small surface near the sphere, the radiance is converted into closed curves between the two. Is there any instance of a really radiant energy being so affected? Does light ever "swirl round" in this way?

Now I am going to contend that the Hertz experiments, examined apart from the fog of assertion which surrounds them, prove that electric energy is not radiant, like light. I say nothing about undulations and nodal points, but I do say that the line of propagation is not radiant, not lines or rays like those of light, but simply the expanding surface of the curves of force uniting the two surfaces of the inductors; that, as in all other electric cases, the origin is dual, and the line is a closed curve growing out into space, just as those of an electro-magnet do. The action induced in the resonator is due to the resonator becoming a part of these curves, just as iron becomes a magnet when occupying a line of magnetic force. Dr. Lodge's metal surface screens the space behind it by taking up the whole of the electric lines, just as iron screens the space behind it from magnetic action. That is very different from being radiant, in the sense that light issuing from a single source is radiant.

§ 5. It is a pity that my suggested experiments do not commend themselves to Prof. Thompson. He says, "a total reflector of energy is yet undiscovered." I thought Dr. Lodge had shown recently that the thinnest film of a conductor entirely shields a so-called resonator from the Hertz effect. Surely that means that energy is not propagated across the screen; but never mind the total reflector. Will Prof. Thompson assert that any screen or reflector whatever will produce the shadow of an influence on the current or the heat of a wire (unless it affects the resistance, by confining or dissipating heat). If the energy enters the wire from the outside, some effect ought to be traceable; it is easy enough to produce an effect by changes in a distant part of the conductor. I must say I am disappointed. I did hope to get some notion as to what the new theory really is. I did not expect it to be proved, but I expected it to be defined, and some notion given as to its operation. As it is, we are just where we were at first. We are expected to believe that energy issues radiant from a source just as light does, and then swirls round and begins to build up a scaffolding of equipotential lines, crystallising upon the conductor, which conducts nothing, not even an impulse, serves no purpose but that of a waste pipe, which light does not require, and generally that this energy swirls about without any guiding force, and yet always finds its way to this conductor. And all this structure of hypothesis and assertion is based upon the imaginary properties of an ether of which our only real knowledge is the single fact that light traverses space, and our minds cannot conceive how it does so unless there is something there to transmit it.

NOTES ON PERMANENT MAGNETS.—II.*

BY PROF. SILVANUS P. THOMPSON, F.R.S.

Maximum Values of Permanent Magnetism.—In the following table are given some of the values of maximum magnetisation retained by actual steel magnets, magnetised by usual processes, and of the "specific magnetisation" σ, or magnetic moment per gramme:—

Observer and Material.	Residual I.	Residual B.	σ.
Weber, common steel magnet	314	3947	40
Von Waltenhofen, Tungsten steel, glass hard	369	4638	47
Schneebeli, sewing-needles 2·5 to 6·6 cm. long, 0·06cm. thick	557 to 671	7001 to 8435	71·4 to 86
Schneebeli, knitting-needles, 19·8 to 21 cm. long, 0·083 to 0·175cm. thick	765 to 832	9626 to 10458	98 to 107
Hopkinson, Tungsten steel, oil-hardened	687	8643	88
" " " very hard	542	6818	70
Ewing, steel wire, glass hard	541	6800	69
" pianoforte wire, glass hard	747	9600	98
Perry, Jowitt's steel	1003	12600	129
Preece, Wall's steel	120	1519	15·5
" Ashforth's steel	143·5	1704	17·3
" Saunderson's steel	114·2	1435	14·6
" Jowitt's steel	109·6	1503	15·3
" Vickers's steel	93·4	1174	12·
" Crewe "rivet steel"	14·8	186·6	1·9
" Crewe "spring steel"	110·5	1391	14·2
" Clemandot steel (compressed and tempered)	170	2264	23·2
" Clemandot steel (compressed but untempered)	106·1	1333	13·6
" Marchal steel	202·2	2540	26·
" Allevard steel (mercury hardened)	104·6	1315	13·4
" " " (water hardened)	132·1	1660	16·9
Gray, magnet steel, glass-hard	520	6536	66
Evershed, Wall's and Jowitt's steels (mean).	318 to 398	4000 to 5000	41 to 51
Brown, magnet steel, glass-hard	477 to 556	6000 to 7000	61 to 72

It is important to note, with respect to the above table, that there is a wide difference in the relative dimensions of the samples used by different observers. The ratio of length to diameter makes, as is known, a great difference to the temporary magnetisation of a specimen; and in the case of permanent magnetisation the differences are even more marked. In Schneebeli's experiments the length used was from 100 to 800 diameters. In Ewing's about 200. Hopkinson's results were with practically endless bars. Perry employed a horseshoe form, closed with an armature of soft iron. Gray† used square bars about 60 diameters long. Brown‡ used cylinders from 33 to 37 diameters; whilst Preece§ used short, square bars, 10 centimetres in length and 1 centimetre in the side. The results given by Preece are the means of several samples of each sort, not the actual best obtained with each. For example, the mean residual **B** for Marchal's steel is given as 2,540, but the best magnet of this sort showed 2,835.

The numbers given in the first column of figures of the last table are the values of the residual *magnetic moment per centimetre cube* of the substance (in C.G.S. measure), and are obtained from the residual **B** by dividing by 4π. Many Continental writers on this subject prefer to give the values in terms of the *magnetic moment per gramme*, a quantity which is also called the *specific magnetisation* of the material. If the density of the specimen is known, the specific magnetisation σ can be calculated from the residual **I** by dividing by the density. For example, taking Gray's figure of 9,804 for the residual **B**, dividing by 4π gives residual **I**, and dividing by 7·8 (which we assume as the density of the steel) gives 100 for the specific magnetisation. In all the preceding table the only samples showing values over 100 for the specific magnetisation are those

* Part I, *The Electrician*, July 3, p. 240.
† *Phil. Mag.*, December, 1885. ‡ *Phil. Mag.*, May, 1887.
§ *The Electrician*, Vol. XXV., p. 547, September 19, 1890.

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obtained by Schneebeli and by Perry. Preece's results for *short* magnets of 10 diameters show specific magnetisations varying from 2 (Crewe "rivet steel") to 26 (Marchal steel).

Ewing found, using enormous magnetising forces which pushed the temporary value of B for Lowmoor and Swedish iron to over 30,000, that the residual values of B were only 510 and 500 respectively, whilst cast iron showed only 400. This means residual I of 40, 39, and 32 respectively, and specific magnetisation of between 6 and 5 only. Du Bois, also using abnormally strong fields, found the residual specific magnetisation for electrolytically deposited nickel 10·6, and for electrolytic iron from 70 to 106.

Influence of Temper and Grain.—In the preparation of permanent magnets, temper is almost as important a consideration as the chemical composition of the material. Most makers have their own favourite method of hardening and tempering, and few can or will give exact particulars. Neither is it possible to give a universal rule as to the best process to follow: for the process of tempering which is best for one brand of steel is different from that which is best for another brand. Tempering does not mean the process of hardening, though careless writers sometimes confuse their meaning by using the term in this erroneous sense. Tempering means the process of letting the steel down to a softer state by a partial re-heating subsequently to the hardening. Moreover, as will be seen, the temper which is best for *short* magnets is quite different from that which is best for *long* magnets and horse-shoe forms. There is, however, no doubt that it is eminently desirable to secure a fine even uniform grain, since any lack of homogeneity tends to reduce the quality of the magnet. An unskilful smith in forging a magnet will spoil its structure by working it too much and unequally. It is commonly supposed that the harder a piece of steel is, the greater retentive power will it exhibit. But under this term two separate qualities must be distinguished. Some steels will show, after magnetisation, a large residual magnetisation, which, however, decays as weeks and months pass away. Some other qualities of steel will exhibit a lesser remanence, but will conserve much longer what they have thus retained. The question of constancy of retention will be separately considered hereafter.

There are several ways of hardening steel. One is by suddenly cooling it from a bright red heat; another is by subjecting it to enormous pressure by hydraulic machinery whilst it slowly cools down. In the former method, which is the usual one, the outer crust cools suddenly, whilst the inner portion is still plastic, and probably compresses it by natural contraction. In the latter method the hardening, though less extreme, is more uniform throughout. It is also possible to harden wires by mere longitudinal traction, as is well known. But this is not used in the manufacture of magnets. If thin rods of steel are heated to a brilliant redness, or even almost to whiteness, and then suddenly plunged into water, oil, or, best of all, mercury, they become intensely hard and brittle, and, indeed, are frequently split in the process. This state is known as *glass-hard*. If the glass-hard steel is then re-heated to near a very dull red heat, for a short time, it softens somewhat, and acquires a pale yellowish tint on the surface, this temper being technically known as *straw-colour*. If it is still further let down, by continuing the re-heating, it becomes *blue* in tint, this temper being used for steel springs, steel pens, and other purposes requiring flexibility. If the re-heating is carried still further the steel becomes soft, being annealed by the continued exposure to a dull red heat. Now, if it were true that the hardest magnets were the best, it is clear that none ought to be tempered down, but all should be left glass-hard, which is not found in practice to be by any means the best course.

Galvanic Estimation of Hardness.—The specification of the degree of hardness by tint is extremely vague. Happily it has been found that steel possesses another and more measurable quality which exists in almost exact proportion to the hardness of the specimen—namely, its electric resistance. Barus,* who examined this fact, and Fromme†, have shown that this relation is very close; and Strouhal and Barus‡ have used this property to specify the hardness of various bars subjected to magnetisation. As an example, they give the following values for a sample of steel:—

State.	Specific resistance in microhms per centimetre cube.
Glass-hard	45·7
Bright straw tint	26·9
Straw tint	26·3
Blue tint	20·5
Bright blue tint	18·4
Soft	15·9

Influence of Form on the Temper that will give a Maximum of Permanent Magnetism.—In all comparisons between hardness and retentiveness, account must be taken of the form of the magnet, for, as already mentioned, short magnets and long magnets possess different properties. In almost all the experiments made on this matter, the steel rods or wires used have been of square or circular section, usually the latter. Consequently, the most convenient way of describing the form of a straight magnet is to state how many times its length is greater than its diameter. In some of Ewing's experiments on soft iron, rods were used varying in length from 50 to 200 diameters, and the results showed that even though the temporary magnetisation was forced up to about the same degree for all, yet the longer rods showed a greater remanence than the short ones. It will be convenient to use the symbol δ for the ratio of length to diameter.

Some important researches were made by Cheesman,* on the effect of hardening by stretching on magnets of different dimensions. Using an English "silver steel" wire (of Messrs. Cook's), 1·28 millims. in diameter and 90 millims. long (*i.e.*, $\delta = 70$) magnetised by contact with a large electro-magnet, he found the result of hardening by stretching to *decrease* the amount of permanent magnetism which the magnet would receive. The magnetising was repeated after each stretching.

—	Stretching weight in kilogrammes.	Specific magnetisation.
Steel, soft	0	78·1
Harder	30	77·3
Still harder	60	70·8
Still harder	70	63·7
(Wire broke)	75	55·6

In another series of experiments the length was varied.

Dimension-ratio. δ	Specific Magnetisation.	
	Soft.	Hard.
22·5	16·4	18·0
40·4	48·0	48·4
58·6	75·6	60·4

From these and numerous other experiments Cheesman concluded that for short magnets hardening the steel increased the retentiveness, whilst for long magnets hardening decreased it. He fixed upon 41 diameters as the critical value of δ for this kind of steel.

Messrs. Strouhal and Barus made a much more searching investigation of the matter, including the question of tempering. They used various sorts of iron and steel; but the results now quoted relate to magnets made of "silver-steel" wire, of Messrs. Cook's, of Sheffield, of diameter 1·48 millimetres, and density 7·7. Of this steel five magnets were prepared, varying from 10 diameters to 50 in length. These were first made glass-hard by sudden cooling in water and then magnetised. They were then subjected to the following processes, their magnetism, after being remagnetised in a coil supplied with current of 80 amperes, from a dynamo machine, being observed (by a magnetometer) from time to time:—Heated (*a*) in steam at 100°C. for one hour, two, three, four hours; (*b*) in anilin vapour at 185deg. for 20 minutes, one hour, two, four, six hours; (*c*) in melting tin at 240deg.; (*d*) in melting lead at 330deg.; (*e*) in melting

* *Wied. Ann.*, Vol. VII., 1879, p. 411.
† *Ib.*, Vol. VIII., 1879, p. 352.
‡ *Ib.*, Vol. XX., 1883, p. 525.

* Cheesman: *Ueber den Einfluss der mechanischen Härte auf die magnetischen Eigenschaften des Stahles und des Eisens.* Inaug-diss., 1882, Leipzig. See also *Wied. Ann.*, XV., 204, and XVI., 712 (1882).

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zinc at 420deg. (this latter temperature is a dull red heat); (*f*) to red heat so as to reduce the steel to complete softness, the magnet being laid in lime in a piece of gas-tubing, and thereafter slowly cooled down. The results, which are of the highest importance, are given in the following table :—

Course of Tempering.	Hardness.	Specific Magnetisations.					
		$\delta =$	9·9	20·3	29·2	40·5	49·8
Glass-hard	43·8	...	24·8	41·0	47·2	50·8	52·5
1 hour in steam at 100°	38·6	...	23·3	39·2	45·2	48·7	50·4
3 hours „ „	36·5	...	23·4	38·6	44·5	47·7	49·3
6 „ „ „	35·1	...	23·3	38·6	44·3	47·4	49·1
10 „ „ „	34·3	...	23·3	38·3	44·2	47·4	48·9
20 min. in anilin vapour at 185°	29·0	...	21·0	38·9	46·0	50·3	52·3
1 hour „ „	27·5	...	21·3	40·2	48·1	52·9	55·1
3 hours „ „	25·6	...	21·6	42·7	52·2	57·7	60·2
7 „ „	24·2	...	21·8	45·5	56·9	63·5	66·8
13 „ „ „	22·9	...	20·9	46·2	59·7	68·1	71·8
10 min. in molten tin at 240°...	22·2	...	20·4	46·7	61·0	70·2	74·3
1 „ „ lead at 330°	19·0	...	19·0	46·7	68·0	83·7	90·0
1 hour „ zinc „ 420°	16·2	...	14·4	40·1	72·6	93·9	103·9
Annealed	14·9	...	4·3	10·2	18·7	29·8	42·4

This table is but one of a large number, all tending to the same general result. The figures given under the column of "Hardness" are the specific electric resistances in microhms. It is interesting to observe how with short magnets the specific magnetisation decreases, then shows a tendency to increase, then decreases again, as the softening proceeds. Another point is that in every case heating in steam slightly reduces the magnetisation that a magnet will retain; but that after some five or six hours a practically constant value is attained.

A very large number of observations with wire of the same sorts were made by these experimenters, with practically identical results. They endeavoured to fix (on the galvanic scale) the actual hardness and magnetic value of their steel when tempered to the tints recognised by workmen, with the following results :—

State of Temper.	Hardness.	Mean Specific Magnetisation.					
		$\delta =$	10	20	30	40	50
Glass-hard	45·7	...	23·5	37·6	43·6	46·5	48·3
Straw-tint	26·3	...	21·4	40·2	49·4	53·8	56·5
Blue-tint	20·5	...	19·3	45·8	67·0	80·4	87·3
Annealed Soft	15·9	...	4·3	11·2	20·5	31·8	44·6

These results agree with those obtained by Ruths,* who found (using another sort of steel) that for short magnets ($\delta = 20$), the specific magnetism fell from glass-hard, 51, to 28·4 when tempered blue, whilst for long magnets ($\delta = 70$) the specific magnetisation which was 68·7 for the glass-hard state, increased to 92 when tempered blue.

Fixidity of Magnetism.—The researches summarised above, important as they are, do not, however, answer the question—what state of temper produces a magnetisation of the greatest constancy in amount? This precious quality, to which Scoresby † gave the name "fixidity," cannot even be predetermined by an inspection of the values of the coercive force, such as have been given by Hopkinson, because these are themselves subject to change with time. Scoresby suggested a method of examining the change of magnetism which was brought about by placing the magnet gently down upon the similar poles of another and more powerful one. He took as the measure of the goodness of a magnet (for the purpose of compass needles, &c.) the product of its original strength into its reduced strength after such treatment. By this method Scoresby (whose magnets were 6in. long, 0·5in. broad, and from 0·5in. to 0·0625in. thick) found the percentage of reduction to be least in cast steel when hard, and to be less when tempered blue throughout than when tempered at the extremities only. Kater ‡ found that for compass needles of *thin* steel it was of advantage to temper down soft the middles of the needles, leaving the ends only hard.

* Ruths. *Ueber den Magnetismus weicher Eisencylinder und verschiedener harter Stahlsorten.* Dortmund, 1876.

† Scoresby. *Magnetical Investigations*, Vol. I., p. 35.

‡ Bakerian Lecture (*Phil. Trans.*), 1821.

THE FRANKFORT EXHIBITION.—V.

(FROM OUR SPECIAL CORRESPONDENT).

The Exhibition is now to all intents and purposes complete. The steam engines and dynamos are in position, the numerous workshops are in operation, and the electric launches are at last running. The 165ft. electric light tower, the various electric transmission of power installations and electric tramways are also in working order. The total number of visitors to the Exhibition up to June 30th was nearly 190,000.

One of the most interesting installations of transmission of power is that connected with the artificial waterfall. Coupled by means of two belts, lying one over the other on the flywheel, to a 100 H.P. tandem engine, by Woolf of the Nuremburg Maschinenban-Aktien-Gesellschaft, are two dynamos transmitting power to two corresponding motors driving two centrifugal pumps. The pumping station is about 100 yards from the driving dynamos in the Machinery Hall, and the work done by the pumps is to deliver about 38 gallons of water per second, to a height of about 10 yards. The centrifugal pumps are by Sulzer Brothers, of Winterthur, in Switzerland; the water pumped by each machine is conveyed in one pipe up to the waterfall, and this union of the streams of water before delivery seems to have the effect of preventing the motors from running quite independently of each other.

One of the dynamos generating the electricity for the use of the motors is an ordinary direct current compound 16-pole machine, by Schuckert, running at 550 revolutions per minute. It is designed to give 38·5 kilowatts, and it drives a corresponding motor coupled direct to one of the pumps.

The other dynamo and its corresponding motor are more novel. The dynamo has an output of 44 kilowatts at 330 revolutions, and the current for the magnet excitation is obtained from accumulators. The machine is of similar construction to the first, but being separately excited it is not provided with a commutator. As the current generated in the armature of a direct current machine is always alternating, when not commutated, the idea here has been to take off two alternating currents from the machine of 90 deg. difference of phase. This has been done by arranging four rings on to the axis of the machine; two of these are connected to the armature coil at opposite extremities of the same diameter; the other two rings are connected in the same way with points on the armature coil at the extremities of a diameter at right angles to the first. The first two rings are joined by two cables to the corresponding rings of the motor, and the second two are also joined to their corresponding motor rings in the same way. The currents of 90 deg. phase difference given to the motor-armature through its rings, at points corresponding to those on the armature of the dynamo from which they were taken, will, if i be the maximum current in each, and if θ is the phase angle of one, give in the ring a current—$i \sin \theta + i \sin (90° + \theta)$, or $i (\sin \theta + \cos \theta)$, or $\sqrt{2}\, i \sin (\theta + 45°)$. This current is in its phase 45 deg. different from each of the alternating currents introduced to the armature and $\sqrt{2}$ times as great as either. In consequence of this current the machine starts automatically. Both the direct current and alternating current motors run singularly smoothly, and up to within a few feet it is nearly impossible to tell whether they are in motion or not, as regards the sound emitted. Before shutting off the current from the motors it is necessary to cut off the connection with the centrifugal pumps; otherwise the latter would let the backflow of water drive them round in the opposite direction.

There is a second dynamo similar in construction to the alternating machine with different phases just mentioned, but it has a commutator in addition to the four rings. A machine of this description can be used for many purposes, as, for instance, in the following cases :—It can be used as ordinary direct current machine, or direct current motor, when current is taken from or sent through the commutator; for a self-exciting alternating current machine from which two currents of 90 deg. phase difference can be taken, the currents of which are independent of each other, and have not necessarily the same maximum strengths, these depending on the resistance of the external circuits; for a machine in which one or both of the above alternating currents can be taken off, and at the

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same time direct current used from the commutator, both for the magnet excitation and for electric lighting, or other purposes. It can, of course, be used as a transformer from alternating to direct currents, and *vice versa*, and lastly as an alternating current motor.

A machine of this kind is at work in the Palm Garden installation. It is driven by a compound engine of from 50 to 60 H.P., by Ruston, Proctor and Co., of Lincoln, which drives at the same time a dynamo by another firm. The Schuckert dynamo generates about 25 E.H.P., at a low voltage, which, after transformation up to 2,000 volts, is economically transmitted by three cables to the Machinery Hall, a distance of about 1,200 yards, where, by means of a suitable step-down transformer, it drives seven motors similar to the alternating one in the pumping station described above. The transformer in the Palm Garden installation is of 20 kilowatts.

The Telephone Installation, erected by Mix and Genest, of Berlin, connecting the Opera House with a small detached building in the grounds of the Electrical Exhibition, proves a decided attraction. This firm has provided, upon the stage of the Opera House, four specially-constructed transmitters, two to transmit the vocal, and two the instrumental, portion of the performance.

THE ELECTRIC TRANSMISSION OF POWER.*

BY GISBERT KAPP.

The transmission of power, in whatever way it may be effected, is one of the most important problems in applied mechanics. Strictly speaking, it enters into and is, indeed, precedent to the application of power to all industrial operations. The power developed in a Lancashire mill-engine only becomes of value to the spinner or weaver after it has been transmitted to the mules or looms by the agency of ropes, belts, pulleys, and other gear. Without such gear effecting the transmission, the power developed by the local steam-engine would be as useless to the mill owner as the power which may be contained in a waterfall miles away. In either case transmission must precede the application of power, but whilst in the former case the problem of transmission is simple, and has to be attacked rather from the point of view of convenient subdivision, than with particular regard to efficiency (this being naturally high with properly designed gear), in the latter case the problem is of a much more difficult character, and efficiency, combined with moderate capital outlay, small working expenses, reliability, and safety become matters of first consideration.

We have thus to distinguish between two kinds of power transmission, the one taking place over distances reckoned by feet or yards, and the other over distances reckoned by thousands of feet, or even by miles. When we speak of the electric transmission of power, we tacitly assume that it belongs to the latter class, and refers to distances beyond the reach of the ordinary gear, such as shafting, cog-wheels, pulleys, and belts, employed for the subdivision and distribution of power within the walls of a factory; and it is in this generally accepted sense that I propose to bring the subject mainly before you. There are, however, cases where the application of electromotors to special tools is either the most convenient or only possible method of applying mechanical power to the performance of certain operations, and it will, therefore, be necessary, at least briefly, to glance at that part of our subject which is not usually comprised within the title of these lectures, namely, the transmission of power over very short distances by means of electric currents. We thus distinguish between "long distance" and "short distance" transmission, the fundamental distinction between the two being that, in the former, the transfer or transmission of power from one point to another, so to speak, in bulk, is our main object; whilst in the latter we rather aim at the subdivision and convenient application of power, in small quantities, at various points, and for particular purposes. I propose to consider long distance transmission first.

Broadly speaking, there are two ways in which we can transmit mechanical energy from one place to another. Let us assume, by way of example, that the primary source of energy is coal, and that the power derivable from this coal is required, not at the pit's mouth, but at a mill a certain number of miles away. In such a case, the obvious, and also the most economical, way of transmitting power is to carry the coal to the mill, and burn it under the boiler of the mill-engine. Even if the distance between the pit and the mill is short, this method will be the best, provided there are no difficulties of transport. Suppose, however, that, although the distance is short, local conditions, such as great difference of level, bad roads, or total absence of roads, render the carriage of coal difficult or impossible, then we would establish our boiler and engine at the pit, generate the power there, and transmit it by wire rope, or in some other way, to the mill. In both cases we have transmission of power, but the methods are essentially different. In the first case we have transmitted, not mechanical, energy itself, but the thing from which mechanical energy can be obtained, namely the coal, each ton of which represents so many stored horse-power hours. In the second case we have transmitted the energy itself in its kinetic or potential form. In popular language we might describe the process as the transmission of "live" power, as distinguished from the transmission of "stored" power, which takes place when we carry coal from the pit's mouth to the mill.

The most important sources of power in nature are corn, coal, and falling water. Under the term "corn" I comprise all vegetable food-stuffs suitable for conversion into mechanical energy, by means of horses and other animal engines; whilst the term "coal" naturally includes all kinds of fuel suitable for conversion into mechanical energy by some form of heat-engine. The power derived from corn and coal is generally transmitted in the stored form; that derived from falling water in the live form, since the conveyance of water at a high level, or under considerable pressure, to great distances necessitates the erection of very costly works. To prevent misunderstanding, I must here point out that I use the term "stored energy," as applied to water, merely in its colloquial sense. We speak of the energy stored in the water of a mill-pond, but, in reality, the energy does not reside in the water at all, but is an effect of its elevated position, and is, therefore, not comparable with the energy which is chemically stored in coal. Leaving, however, such distinctions on one side at present, we may regard water, which is being carried along horizontally, at a certain elevation, from one place to another, as the vehicle of so much stored energy, which we can obtain, in its live form, at any point at which we establish a water-engine, through which the water passes in its descent to a lower level. If we carry water along in this way, it is not with the object of bringing the stored power to the point of application, but merely to secure the largest possible fall, and, therefore, a maximum of power with a given quantity of water. If it be necessary to transmit the power farther, the transmission is generally effected in the live form. Now let us see what position electricity occupies in relation to these primary sources of power in nature, namely, corn, coal, and falling water.

In the first place it will be obvious that, where electricity is the transmitting agent, we can effect the transmission both in the stored and in the live form. To see this clearly, we need only for a moment revert to our example of the coal pit and the mill. Instead of sending the coal to the mill to be converted into power there, we could burn it at the pit, and thereby generate steam to be used for driving a steam dynamo. The current from the dynamo we could utilise in charging a storage battery, and send this to the mill, where it would drive an electromotor, thus taking the place of the local steam engine. Here we have a system of transmitting energy in the stored form. On the other hand, if we do away with the batteries as a vehicle of energy, and connect the dynamo at the pit with the motor at the mill by a pair of insulated wires, we have a system of electric transmission of power in the live form. The latter system is that generally understood under the term "electric transmission of power," and therefore forms the principal subject of these lectures; but before entering upon it, I propose briefly to investigate the capabilities of electric transmission of power in the stored form.

As you all know, a sack of coal contains more stored power than a secondary battery of equal weight, and its carriage, whether by rail or road, is cheaper, easier, and requires less precautions than that of the battery. It is, therefore, quite obvious that, if the primary source of power is coal, and if there is no objection to the establishment of a steam-engine at the place where the power is wanted, it will be more economical to carry the power there in the form of coal than in the form of batteries; not only because of the saving in carriage, but also on account of the smaller capital outlay, the smaller depreciation, and the avoidance of the loss of energy in the battery itself. But let us assume that the primary source of energy is falling water, then it is not so obvious at the first glance that its electric transmission in the stored form should be uneconomical. We cannot produce coal out of the energy of falling water, but we can charge batteries with it, and electricity would thus seem to offer a means of utilising a power of nature which would otherwise be lost. It might, perhaps, here be objected that electricity does not form the only means for utilising such a power, since there are various other ways in which power may be stored, a familiar example being compressed air. We might therefore, also utilise the power of the waterfall for working an air compressor, and store the air under pressure in steel reservoirs, to be used afterwards for working air-engines constructed similarly to ordinary steam-engines. Many such engines are actually in use in Paris on the Popp system, though there the air is conveyed to them by pipes under pressure, and not in

* Cantor Lecture I., delivered before the Society of Arts, February 16, 1891.

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storage vessels, as would be the case in our example. There can thus be no doubt that the transmission of power by stored air is practicable, but the question is, at what cost will it be effected, and can it compete with transmission by batteries? The answer to these questions depends on two factors, namely, the storage efficiency and the cost of transport. By storage efficiency, I mean the ratio of the power put into and taken out of the apparatus which serves as the vehicle for the power. Batteries may now be obtained in which this ratio is about 80 per cent.; that is to say, for every 100 H.P. hours put into the battery, 80 H.P. hours can be taken out. The storage efficiency of compressed air is very much smaller. The most reliable data under this head are to be obtained from the Paper which Prof. Kennedy read before the British Association in 1889, when he gave an account of experiments carried out at Paris on the Popp system. He found that the indicated efficiency with cold air was 39 per cent.; that is to say, for every 100 H.P. indicated by the compressing-engine, 39 H.P. were indicated in the engine driven by compressed air as it came from the mains. If the air before being admitted to the engine was heated to 320°F., the apparent indicated efficiency rose to 54 per cent., but as the heat energy thus supplied to the air requires the expenditure of fuel at the point where the power is wanted, the use of hot air really involves two methods of transmission—namely, that of power in the shape of air under pressure flowing through the mains, and that of power in the stored form contained in the fuel. To make the comparison with electric transmission of stored power a fair one, I must therefore take the efficiency of the Popp system when the air is not heated. A correction must, however, be made for loss of power in the mains. In the Popp system the power is transmitted in the live form by air flowing through pipes, and there is necessarily a certain loss on account of friction in the pipes and valves. As far as the friction in the pipes is concerned, this would not occur if the transmission were effected in the stored form by means of air carried under pressure in a reservoir, but, on the other hand, the loss by friction through valves would be greater, because it would be necessary to insert between the reservoir and the air-engine a reducing valve, which would regulate the supply of air as the pressure falls. The loss of power due to this circumstance will probably be greater than the corresponding loss in the Popp system, where the pressure is constant; but as I have no experimental data to determine this point, I take the same loss as found by Prof. Kennedy, namely, 2 per cent., which makes the indicated efficiency nearly 40 per cent. The efficiency of the air-engine he found to be, with cold air, 67 per cent., making the total efficiency of the system 26·7 per cent. By adopting air storage we could, therefore, obtain 26¾ H.P. hours for every 100 H.P. hours indicated in the engine. Now let us see how the case stands with electrical storage. The efficiency of the steam dynamo, that is, the ratio of the electrical output to the indicated power, may be taken as 83 per cent., that of the batteries 80 per cent., and that of the motor at least 85 per cent.; so that the total efficiency works out to quite 56 per cent., or more than twice that of the rival system. I have here assumed that the dynamo is steam-driven, simply because the only reliable figures I could obtain about compressed air referred to steam-driven compressors, but it is obvious that the comparison of the storage efficiencies of the two systems cannot be materially affected by the source of power, and will practically be the same in the case under consideration, where the power is supposed to be derived from falling water. We see that in efficiency, at least, air storage is far behind electrical storage. Let us now inquire whether it is any better off in the other essential feature I have mentioned—namely, in the cost of carriage. The information available under this head is tolerably reliable as regards batteries, but this is not the case as regards air stored under pressure. I know of no experiments made to determine accurately the weight of air reservoirs, and, in the absence of such data, I cannot do better than adopt the calculated figure given by Prof. Osborne Reynolds in one of his Cantor lectures delivered in 1888. According to this authority, the weight of the steel reservoir and air contained would amount to 300lb. for ever horse-power hour so stored. Now the weight of a secondary battery filled with liquid, and provided with a tray and connections, all complete, does not exceed 100lb. per horse-power hour stored, that is, only one-third the weight of an equivalent air reservoir. We see, therefore, that as regards efficiency air storage is twice as bad, and as regards weight it is three times as bad as electric storage. Competition with it is, under these circumstances, obviously impossible, and we may therefore say that if the transmission of power from the waterfall to a distant point has to be made in the stored form, electricity is the only agent which need be considered.

Whether it would pay so to transmit power is a question which cannot be answered off-hand. As compared with the direct transmission of live power by means of a pair of wires, the cartage of batteries up and down the country will no doubt appear to be a clumsy device, but when we are investigating the different possible solutions of an important problem we must not allow any preconceived opinions of what is elegant or clumsy to influence our judgment; we must, in fact, judge each case on its own merits, and I propose to deal with the electric transmission of stored energy in this sense. The system of power transmission by storage batteries is actually in use, not, indeed, for long distance transmission pure and simple, as above defined, but still for transmission over distances reckoned by miles. I allude to the electric tram-cars worked by storage batteries, which are charged at a central depot, and run for many miles before they require to be again charged. The object is not to carry a certain amount of power in bulk from one point to another, but to dispense whatever power is required for the propulsion of the car during the journey. We might, however, imagine the tram-car, instead of being occupied by passengers, to be loaded with storage cells in addition to those it carries for its own propulsion. Whilst the latter would gradually lose their charge in transit between the two terminuses, the former would arrive fully charged, and could be made to give up part of the power stored in them at the starting point. Here we have transmission of power in the stored form, but let us return to our example of the waterfall and the mill, and see how such a system might be put into operation.

At the waterfall we establish the necessary hydraulic works, and an electric station where the batteries can be conveniently charged. We further build a tram line or railway, joining the charging station with the mill where the power is wanted, and we design the rolling stock with special regard to the safe and convenient carriage of the batteries to and fro. The train is fitted with electromotors, so as to make it self-propelling. A train load of charged cells is thus taken to the mill, and left there to work the electromotor which supplies power to the mill During this process the batteries become gradually exhausted, and must be disconnected from the motor before they are quite exhausted, because we must allow a sufficient margin of power for taking the train back to the charging station. The economy of the whole system will evidently be the greater the less power is spent in the outward and home journey; and we might call "efficiency of transmission" the ratio of the power actually delivered to the motor, and that which might be so delivered if the battery were used for working a motor at the charging station itself; in other words, if the distance of transmission were nought. Say, for instance, that a total of 1,000 H.P. hours could be obtained from the battery, if it were discharged immediately, and that the power spent in the outward journey amounts to 50 H.P. hours, then a further 50 H.P. hours will have to be spent in the return journey, and the power obtainable at the mill will only amount to 900 H.P. hours. The efficiency of transmission will, in this case, be 90 per cent. If we double the distance between the waterfall and the mill, the efficiency of transmission would be reduced to 80 per cent; if we treble the distance, the efficiency would only be 70 per cent., and so on. The efficiency must naturally depend on the kind of road over which the transmission takes place; it will be small on a common carriage road, larger on a tramway, larger still on a railway, and largest on a canal. We can, for every arrangement, express the value of the system, as far as economy of power is concerned, in one of two ways. We can, if the distance is fixed, give the efficiency in the usual way as a percentage, or we can fix a standard percentage of efficiency, and ascertain the distance over which this standard is attainable in any particular case. I shall adopt the latter way of reckoning, as the more convenient for comparison with other methods for transmitting power, whether in the stored or live form.

First, as to transmission of stored power otherwise than by batteries. The only two methods we need consider are the carriage of corn and the carriage of coal, each combined with the use of a proper engine for converting the stored into live power at the other terminus of the iine of transmission. In the case of corn, the starting point of this line is the field where the corn is grown. We there load it into suitable vehicles, and send it to the mill where the power is wanted. Since we are dealing now entirely with animal power, we must suppose the cartage to be effected by draft animals, say horses, and the conversion of corn into live power at the mill also by such animals. I need hardly say that, at the present time, no English mill owner would dream of working his mill in this fashion by animal power, since coal is yet abundant, and a single steam-engine is a far cheaper and handier instrument for producing and controlling a large amount of power than an equivalent number of horses. On the other hand, if power is required in small quantities, and in particular ways, then the horse will produce this power better, more cheaply, ahd more conveniently than the steam-engine. It may seem absurd to work a large cotton mill by horse gear, but substitute for the mill a farm, and you see at once that the transmission of stored power to it, in the shape of corn, is a necessary part of the agricultural operations. Now, the horses, in bringing the corn to the place where the power is required, perform work, and must consume an equivalent amount of food. They also perform work in bringing the empty carts back again to the field to be re-charged. The ratio between the amount of corn delivered at the mill and the amount taken out of the field would therefore re-

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present the efficiency of transmission. If this is to be 90 per cent., as in the case of electric transmission, we may take it that, for every 100 sacks of corn taken away from the field, the horses would eat on the outward journey (when the carts are heavily laden) 6½ sacks, and on the homeward journey (when they are empty) 3½ sacks, leaving 90 sacks of corn to be converted into live power at the mill. The distance to which we can thus carry stored power with a standard efficiency of transmission is a measure of the merit of the system, as far as economy of power is concerned.

The transmission of stored power in the shape of fuel is a parallel case. We load the coal at the pit's mouth into waggons, and haul them by means of locomotive engines to the places where the power is wanted. Part of the coal is consumed on the outward and homeward journey of the train, leaving the rest for the production of live power at the mill. If this amounts to 90 tons out of every 100 tons put on the train at the pit's mouth, we have again an efficiency of transmission of 90 per cent.

I have already mentioned that the exact distance to which we can carry power by either of the three agents here mentioned (namely, batteries, corn, and coal) depends very much on the kind of road over which the transmission takes place. We might assume an almost infinite variety of cases, but, as our object is to obtain a rough general comparison of the different systems rather than exact figures for any one of them, I have assumed merely three kinds of roads, namely, a common carriage road, a tramway, and railway, and have calculated the distance to which power can be transmitted in each case with a loss of 10 per cent. The results of these calculations are given in the following table. The speed of transmission has been assumed at four, six, and twenty miles for road, tram, and rail respectively, when coal or batteries are the transmitting agents; and at four miles on all kinds of road where corn is the transmitting agent. In all cases I have assumed that the road is the best of its kind, perfectly free from gradients or curves, and that the traffic can be worked at the speeds mentioned without interruption. In reality, these conditions will of course not all be fulfilled; we have to make allowances for waste of power on gradients, curves, bad places in the road, for running at variable speed, and for stopping and starting. The distances given in the table are, therefore, throughout too large; but, as our purpose is merely the comparison of the different systems, we may take the figures in the table as a rough indication of the merits of each.

Transmission of Stored Power.

Source of power.	Distance in miles attainable with 90 per cent. efficiency of transmission over :—		
	Road.	Tram.	Rail.
Coal and steam engine	115	270	1,300
Corn and horse	52	170	440
Storage battery and electromotor	4	10	26

You will see, from this table, that as regards efficiency, the electric transmission of stored power cannot compete with the other two methods. A horse and cart carrying corn over an ordinary carriage road works with twice the efficiency of the electric locomotive taking batteries over a railway. The discrepancy is still greater if we compare the electric locomotive hauling batteries with the steam locomotive hauling coal. The latter can transmit power over a distance fifty times that over which the former can transmit power with an equal efficiency. On a tram line the distance over which we can transmit power with an efficiency of 90 per cent. is, according to the table, 10 miles; that is to say, if the whole load of the car is composed of batteries, we can run it 10 miles out and 10 miles home at an expenditure of 10 per cent. of the total charge of the batteries. Now let us see how this compares with the storage cars in use on passenger tram lines. The total weight of a full-sized car is about 10 tons, made up somewhat as follows :—Car and propelling gear, 4 tons; batteries, 2½ tons; passengers, 3½ tons. If the 3½ tons represented by the passengers were utilised for additional storage cells, the car could run 20 miles with the loss of 10 per cent. of its charge; or it could run 200 miles if losing the whole of its charge. As there are, however, only 2½ tons of batteries instead of 6 tons, it can only run 86 miles. This is according to the table, and more than attainable in practice, for the reasons already stated. Experience has shown that storage cars can only run from 30 to 60 miles with one set of batteries, or half the distance stated in the table. If we apply the same reduction to all the methods of transmission, we find that the distances to which power can be carried electrically in the stored form, with an efficiency of 90 per cent., are two, five, and 18 miles over a carriage road, tramway, and railway respectively.

The efficiency of transmission is, however, not the only or even the most important consideration in the problem of transmitting power to a distance. The owner of a transmission plant cares nothing for any theoretical perfection in the way of high efficiency. All he cares for is the cost at which the power is delivered to him. All other things being equal, high efficiency will naturally reduce this cost, and, in so far, is an advantage, but in practice all other things are not equal, and to aim at high efficiency regardless of other considerations is the reverse of good engineering. It is no doubt gratifying to the engineer if he can point to a transmission plant designed by him to give some extraordinarily high efficiency, but if this result has been obtained by means of an exorbitant capital outlay and excessive working expenses, it will not be equally gratifying to his employer, the owner of the installation, who has to pay for its erection and working. It therefore becomes the duty of the engineer so to plan the installation that the cost of the power delivered shall be a minimum under any given circumstances.

We have seen that, as judged by the efficiency standard alone, electric transmission of power in the stored form is hopelessly behind the other two methods which we compared with it. Let us now see whether this is or is not the case if we judge the system by the more practical and, indeed, the only reliable test of cost. It is, of course, understood that, in estimating the annual cost at so many pounds per horse-power delivered, we take into account not only the cost of coal burnt throughout the year, if we obtain the power by steam, or the rent for water if we use a turbine, but also all other expenses which may properly be charged to the power account, such as wages for the attendants, petty stores, interest, repairs, and depreciation of plant. Estimated in this way, the cost of water power will be found to vary between £2 and £8 per annum, the exact figure depending, of course, on the total amount of power available, the quantity of water, its fall and local conditions, which must largely influence the cost of the hydraulic works. The cases where water-power can be had at so low a price as £2 a year are exceptional; on the other hand, if we have to pay as much as £8 a year for water-power, it will seldom be worth while to transmit it electrically, or in any other way; and I shall, therefore, assume £3 and £6 as the limits of cost for water-power intended for electric transmission. The cost of steam power, if produced by large economical engines, is generally taken at £10 per year; if produced by small, and therefore less economical engines, it may rise to £20, and even £40 per year. I shall further assume that in all cases the power is required for 3,000 hours during the year, that is, 300 working days of 10 hours. At the outset, it is clear that if we wish to transmit large parcels of power—say 100 H.P. and upwards—by storage batteries, we must be able to deliver the power at a cost higher, it would obviously pay better to establish a local steam-engine. I have already mentioned that a system of battery transmission can be made to yield 56 per cent. efficiency, if we allow 10 per cent. for the transmission itself. To deliver 100 H.P. we must, therefore, charge with 178 H.P. during a time equal to that during which the power is required. If, therefore, at the generating station the annual horse-power costs £3, the charge for power alone will be £5. 6s. at the receiving station. To this must be added the cost of labour and the interest and depreciation of plant, which, in this case, consists of the generating dynamo, motor batteries, and line of transmission, with its equipment of locomotives and waggons. The small storage cells, as now made, for lighting and power purposes, cost about £40 per horse-power; but let us assume that the larger cells, such as we would require, could be had for £30 per horse-power, then a battery to work a 100 H.P. motor would cost £3,330. In order to economise carriage, and to reduce the wear and tear of cells, it would be advantageous to have two batteries, one being charged while the other is at work. We have thus an initial outlay of £6,660 for batteries alone. The interest and depreciation on these will certainly not be less than 15 per cent., or £10 per horse-power. Add to this, the cost of power at the generating station, that of labour and interest and depreciation on the electric machinery and the line, and you will see that it is quite impossible to compete with battery transmission against a local steam-engine, if the power produced by the latter costs £10 per annum. But how does the case stand, if the amount of power required is so small that it cannot be produced at this low figure? If we want only 5 H.P., and if we produce it by a local steam or gas engine, we shall have to pay for each horse-power £20 to £40 per annum. Will it, in this case, pay to transmit, by means of batteries, the power produced by a large and economical steam-engine at some central station? If we have to build a tramway or railway for this purpose specially, it will certainly not pay; but let us assume that a tramway already exists, and let us investigate whether the company, which we suppose is working the line by storage cars, could afford to sell to a customer on the line power at a cheaper rate than he could produce by a local engine. Let us assume, by way of example, that the customer requires 5 H.P. for 10 hours daily. The battery to work a 5 H.P. motor will weigh about 2½ tons, and cost £170. The charging dynamo, motor, and regulating gear will cost about £150, so that the whole capital outlay, if we provide two batteries, will amount to £490.

(To be continued.)

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ELECTRIC LIGHTING BY MUNICIPAL AUTHORITIES.*

BY PROF. HENRY ROBINSON, M.I.C.E., M.I.E.E.

The supply of electricity to the community may now be regarded as one of the requirements of the day, and it is of first importance to municipal authorities to consider the expediency of preserving the supply in their own hands. Many have lost the opportunity, and have allowed companies to obtain powers over their areas. Many are now deliberating upon the point or are in conflict with companies, and, as I think, the question is ripe for decision, and I hold that it is not so advantageous for these undertakings to be carried out by private enterprise, and by outside capital, as it is by capital raised on the rates, whether from a financial or public point.

As regards finance, the authority can provide the necessary capital at a far lower rate than a company can; and as regards convenience, the public lighting of the streets, the disturbance of roads, and the sanitary advantages of substituting electric light for gas in dwellings, point to their being matters that clearly devolve on the authority to deal with.

I think it will be useful to put on record in your *Proceedings* calculations that I have made of the relative cost of gas and electricity which have appeared in various reports of mine, when advised on the subject of electric lighting.

Table *showing Cost of Gas Lighting.*

Description of Burner.	Candle-power.	Comsumption of gas per hour per lamp.	Candle-power per cubic foot used per hour.	Cost per hour with gas at 2s. 9d. per 1,000 cub. ft.	
				Per lamp.	Per c.p.
		Cubic ft.		Pence.	Pence.
Ordinary batswing ...	10	4·3	2½	·142	·0142
Flat flame from ...	11·5	4·6	2½	·152	·0132
Flat flame to ...	13·8	4·6	3	·152	·0110
Flat flames in clusters	60	15	4	·495	·0083
	90	20	4½	·66	·0073
	150	30	5	·99	·0066
Special form requiring motive power ...	120	10	12	·33	·0028

On an average, it may be assumed that each private lamp in London will be used for 1½ to 2 hours per day throughout the year, whilst in the suburbs it will be used 1 to 1½ hours per day. In shops open till nine o'clock, each lamp will be used three hours per day, and for public-houses, restaurants, &c., each lamp will be used four to five hours per day throughout the year. The annual cost of gas would thus be in a private house with 30 lights used on an average 1½ hours a day, or 547 hours per annum:—

	£	s.	d.
547 × 30 = 16,410 lamp hours at ·152d. ...	= 10	7	11
Add for rent of meter ...	0	14	0
Annual cost ...	£11	1	11

The cost of gas-piping and ordinary (not ornamental) fittings may be taken as follows:—

Workshops and factories ...	20s. to 25s. per light.
Shops ...	25s. to 35s. „
Private houses (with 20 to 40 lights) ...	30s. to 40s. „

The actual cost of producing a Board of Trade unit of electricity may be taken at about 2½d., excluding the provision for the sinking fund, or 3½d. per unit including that provision. At the rate of 3½d. per unit the cost would be as follows:—

·0135 × 12½ = ·169d. per lamp hour, including renewals.

	£	s.	d.
16,410 lamp hours at 169d. ...	11	11	1
Add for rent of meter ...	0	14	0
Total ...	£12	5	1

If the current is charged at 6d. per unit (which is lower than most companies charge, and will yield a profit to the authority) the cost per candle-power per hour will be about ·022d. per lamp hour, or 0·275d. including renewals, in which latter case the cost of the 12 c.p. lamp would be £19. 10s. per annum, instead of £12. 5s. 1d.

For workshops and factories the cost of ordinary fittings for electric light will be from 25s. to 30s. per lamp.

Shops ...	30s. to 40s. per lamp.
Private houses (with 20 to 40 lights) ...	35s. to 45s. „

I will next deal with public lighting, which concerns municipal authorities very closely. For street lighting the arc light is the most economical. The smallest size of arc lamp at present manufactured requires a current of about five amperes, but for steadiness and efficiency it is desirable not to use less than six amperes. The candle-power of arc lamps varies considerably according to the angle at which it is measured. The greatest intensity with continuous-current lamps is found at an angle of about 40deg. below the horizontal line. The following table gives the approximate candle-power at various angles. The height of the lamps should be arranged so as to give an angle of not less than 7deg. to the most distant point which it is intended to serve:—

Lighting Power of Arc Lamps.

Current in amperes.	Horizontal.	At angle of 7°.	At angle of 10°.	At angle of 20°.	Maximum at angle of 40°.
	c.p.	c.p.	c.p.	c.p.	c.p.
6	92	175	207	322	460
8	156	300	350	546	780
10	220	420	495	770	1,100

The following table gives the cost of working arc lamps:—

Current in amperes.	Average candle-power at angle of 20deg.	Watts required.	Units used per hour.	Cost of current at 3½d. per unit.	Cost of carbons ·50 and fixing ·16.	Total cost per lamp hour.	Cost per average candle-power per hour.
				Pence.	Pence.	Pence.	Pence.
6	322	300	0·3	1·05	0·66	1·71	·00531
8	546	400	0·4	1·40	0·66	2·06	·00377
10	770	500	0·5	1·75	0·66	4·21	·00313

The last column in the table gives the cost per candle-power per hour, and these figures are arrived at by dividing the "total cost per lamp hour" by the figures representing candle-powers "at an angle of 20deg." (given in the table of lighting power), which represents a fair average of the power from arc lamps. The last column in the table of cost admits of comparison with the last column of the table previously given of the cost of gas.

Arc lights should be placed high up for the following reasons:—1. On account of their high candle-power and great distance apart. 2. Because the light thrown down at an angle is much greater than that cast horizontally. 3. Because the light given horizontally is not so steady as that which is thrown down at an angle.

The following data enable the coefficient of minimum lighting power in streets to be determined:—

Let P = candle-power of lamps.
L = maximum distance from lamp in feet.
H = height of lamp in feet.
X = a coefficient.

The light falling on a unit area of pavement varies inversely as the square of the distance from the lamp, and is directly proportional to the angle at which it falls. This angle is nearly proportional to the height of the lamp divided by the distance. Therefore,

$$X = \frac{P}{L^2} \times \frac{H}{L},$$

or

$$X = \frac{P\,H}{L^3}.$$

The usual standard of gas lighting is represented by the amount of light falling on a unit area of pavement 50ft. away from a 12 c.p. gas lamp 9ft. high, which gives a co-efficient as follows:—

$$X = 12 \times 9/50^3 = ·000864.$$

Adopting the above coefficient, I calculate that the before mentioned sizes of arc lights will give the same standard of light at the heights and distances stated in Table A.

Table A.

Current in amperes.	Height of lamps.			
	20ft.	25ft.	30ft.	35ft.
	Maximum distances served from lamp in feet.			
6	160	175	190	202
8	185	202	220	235
10	205	225	243	260

Table B gives the corresponding distances, assuming the minimum standard to be doubled, thus bringing the coefficient up to

* Abstract of a Paper read before the London Meeting of the Association of Municipal and County Engineers.

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·001728, which represents the amount of light on a unit area 50ft. away from a 24 c p. lamp 9ft. high :—

Table B.

Current in amperes.	Height of Lamps.			
	20ft.	25ft.	30ft.	35ft.
6	130	144	155	166
8	150	165	180	193
10	170	190	205	220

The distances the lamps are apart would, of course, be double the distances mentioned in tables A and B.

One arc lamp will take the place of from three to six gas lamps, according to the locality, arrangement, and standard of light adopted.

A scheme of arc lighting, based on the substitution of one arc light on the average for 3½ to 4 gas lamps, would double the minimum standard of light, whilst the average standard would be increased 10 or 12 times.

Placing lamps along the middle or the streets has the advantage of illuminating the fronts of the houses more uniformly, and this advantage is more apparent when the lamps are of higher candle-power than that of the present gas lamps. Moreover, in business thoroughfares the footways are often fairly illuminated by the shop-lights, whereas the middle of the road is thrown more into shadow. The regulation of traffic in crowded thoroughfares would be much assisted by a well-considered system of large lights and shelters or refuges, and the cost of police control over traffic in streets likely to become congested would be reduced thereby, whilst the number of accidents would diminish.

A higher standard of street lighting appears to be inevitable in the near future, even if it is attended with increased cost. This is evidenced by the fact that authorities are now directing their attention to affording a much larger amount of light in main thoroughfares than has heretofore been accepted as sufficient. In carrying out a system of public lighting by electricity, the fact that the lights can be instantaneously switched on and off at a central station may be taken into account. By having a second main, and by connecting the lamps alternately to the two mains, every alternate light could be switched off at, say, midnight, and a saving effected in the annual cost. It should be noticed that with public gas lamps an appreciable time is taken up in the operation of lighting and extinguishing, by which the lamps that are first lighted and last extinguished have been consuming gas beyond the actual time that is needed for lighting purposes. A series of electric lights, on the other hand, admit of being switched on and off at the central station at the exact time required by the season, so that practically the number of lamp hours in the case of electric lights is less than with gas lights to the extent of several hundred lamp hours per annum.

THE GORDON CLOSED CULVERT SYSTEM OF ELECTRIC TRACTION.*

There are four well-known methods of conveying the electrical energy from the central station to the motor on the car.

The Storage System.—This system possesses the great advantage that it can be applied to existing tramways without any alteration in the permanent way, provided the latter has been built sufficiently strong to stand the great weight of these cars and the increased wear and tear. Unfortunately, however, the system is very costly both to instal and in running expenses.

Overhead System.—In this system bare conductors are led overhead from the central station along the whole length of the track, and connection is made between this and the motor on the car by means of a pole attached to the roof of the car. The unsightly poles and cross-arms erected along the street are an eyesore and inconvenience to the public, and all the objections against overhead telegraph and telephone lines apply with much greater force to overhead tramway lines. It may be taken as a foregone conclusion that neither in Great Britain nor in most of the principal Continental towns will the overhead system ever be tolerated.

Open Culvert System.—This system has produced most excellent results, but is very costly to instal. It involves digging up the concrete foundation to a considerable depth, and almost rebuilding the tramway.

Closed Culvert System.—In this system a surface conductor is formed of a series of short lengths of mechanically strong conductor, fairly well insulated from one another, usually running along midway between the permanent way rails, and with their upper surfaces flush with the roadway. Underneath is a closed culvert, containing a well-insulated and main conductor leading from the central station, but the short lengths of surface conductor are electrically connected with the main conductor only when covered by a passing car. My object is to bring before your notice a new method of working this system which solves all the difficulties and meets all the requirements mentioned above.

The Gordon Closed Culvert System is an improved surface conductor system, the improvements being chiefly in the means of establishing and breaking connection between the main conductor and the surface conductors, in simplification of the closed culvert, and in dispensing with all moving parts under the roadway. Extensive experiments on this system have been carried out during the past 12 months on a full gauge line at Messrs. Merryweather and Sons' Engine and Tramway Works, Greenwich, S.E., with the most satisfactory and encouraging results. In the Gordon system, instead of using a complicated automatic mechanism for each short length of surface conductor, a number of such conductors are grouped into a section, and one electro-magnetic switch or distributor works the whole group. As the surface conductors are about 8 or 9ft. long, and 30 or thereabouts are grouped into a section, the distributors are few in number—about 20 per mile—and spaced about 90 yards apart. They may, therefore, be placed advantageously in boxes under the pavement, immediately inside the kerb stone, and the conductors may be tested, withdrawn, and replaced with little or no disturbance to the traffic. The culvert is the simplest imaginable, being an ordinary 2½in. gas pipe with T-pieces every 16 or 18ft., that is, opposite every alternate break in the surface conductor. At or about the centre of each group of surface conductors, this longitudinal pipe is fitted with a small T-shaped junction box from which a cross pipe leads to the distributor box under the pavement. The top of this T-shaped junction box is movable, to facilitate the drawing in and out of conductors. The main well insulated conductor is placed in a longitudinal pipe along the length of the track, and from it a branch is led to each distributor box through the cross pipes. The openings in the T pieces in the longitudinal pipe are plugged, and through the plugs are led well-insulated service leads, one from each short length of service conductor to the distributor which operates the section of which it forms an element. It might at first strike one that this plan involves a great outlay in insulated copper conductors, but such is not the case. With 30 lengths of surface conductor per section the total length of service leads is seven miles per mile of track, and as a car is always supplied by two service leads in parallel, each has to carry only one half the current necessary for one car during the time occupied in travelling over 8 to 9ft—that is to say, about one second at normal speed. The service leads may, therefore, be of comparatively small section. A 7/18 conductor will be sufficient for all ordinary requirements. The fall of potential has to be considered rather than the carrying capacity, as the absence of sparks in the distributor depends upon the former being kept small. The small outlay in service leads is more than compensated for by the absence of moving mechanism under the roadway, the simplicity and small dimensions of the conduit, and the consequent minimum of disturbance to the existing track involved in adopting it to this system.

The distributors are simply a number of electro-magnets (one for each length of surface conductor) excited by a shunt current only. (One terminal of each is connected to the corresponding service lead and the other terminal to the return). Each magnet operates three contacts, one when it is excited and two when it is not excited. Of the latter two, only one is actually in use at any given time, which one depending upon the direction in which the car is travelling. The connections are so arranged that before the car can receive a supply through any given surface conductor the corresponding magnet must be excited, and the two magnets corresponding to the surface conductors next but one in advance and next but one in rear must not be excited. The car carries two collectors, or slippers, placed apart about one-third the length of the car, and electrically connected together, and to one terminal of the motor. These rub or slide along the surface conductor, and the current, after passing through the motor, is led through the permanent way rails back to the source of supply. (In cases where the use of the rails as a return might be objected to, an insulated return can be provided without the introduction of additional surface conductors into the roadway, and at a small extra cost). As the car advances, and the forward collector touches a surface conductor not yet charged, the latter becomes charged by reason of being short circuited with the charged conductors in rear. A current passes through the corresponding service lead and magnet to earth, and the latter, becoming excited, operates two contacts, one of which puts the surface conductor just entered upon into communication with the main conductor, the other at the same time cutting out the next but one in rear. During this operation the car receives its current through the surface conductor lying between these two.

* Abstract of a Paper read before the Tramways Institute, on July 2nd, by Mr. John Gordon.

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The main current is thus never interrupted. When no current is required, as, for instance, when the car is at rest or going down hill, the conductors under the car are always charged, the current used to propel the car operating in no way to effect this. This result is brought about by the combined movements of the collectors along the surface conductor, and of the contact makers in the distributors. I have stated that when any magnet is not magnetised it closes two contacts, but that only one of these is in use at any given time. This arrangement is to enable the car to proceed in either direction at any moment. The experiments on this system, which have been carried out at the works of Messrs. Merryweather and Sons under circumstances so trying as to put a severe strain on any system, have been attended with such success as to justify the anticipations of those who were made acquainted with the system, and satisfy its supporters as to its practicability and ultimate success. The work had to be carried on without interfering with the busy traffic in a large engineering works; the track has been repeatedly flooded with water during the testing of fire engines, and the distributors themselves have frequently come in for an occasional copious shower bath. It has been suggested to the writer that, if the track were very wet, a current sufficiently large to energise one of the magnets might leak across from a charged surface conductor to the adjoining one, and thus put the movements in the distributor out of step, so to speak, with the movement of the car. Were such the case the difficulty could be easily and effectually remedied by attaching to the rear end of the car a supplementary slipper, electrically connected to the frame of the car or to the return lead. This would put each length of surface conductor to earth or zero potential immediately the car passed over it. In practice, however, it has been found sufficient to make the distance between the surface conductors about three inches; but the above device, being so simple, might be advantageously used as an additional security against any possibility of the distributor getting out of step with the car or a charged surface conductor being left exposed. The cost of adapting an existing tramway to this system would be about £2,000 per mile of single track.

PARLIAMENTARY INTELLIGENCE.

THE CHELSEA ELECTRIC LIGHTING PROVISIONAL ORDER.

The Select Committee of the House of Lords, presided over by Lord Basing, had before them, on Thursday, the Electric Lighting Provisional Orders (No. 10) Bill, which confirms certain Provisional Orders, relating to the City of London, Clerkenwell, Middlesex, Woolwich, and St, Luke (Chelsea). The Bill was unopposed except with reference to the St. Luke (Chelsea) Order, which confers power upon the new Cadogan and Belgrave Electric Supply Company to supply the electric light to a part of the parish of St. Luke, Chelsea. The Vestry of Chelsea petitioned against this Order, on the ground that, if it passed in its present form, the district over which they had control would be injuriously affected.

Mr. T. Holland, clerk to the Vestry of Chelsea, appeared to oppose the Bill; Mr. Cripps, parliamentary agent, supported it on behalf of the London County Council; and Mr. Muir Mackenzie represented the promoters.

Mr. HOLLAND, on behalf of the Chelsea Vestry, said the Order, as drawn up by the Board of Trade, contained clauses making the London County Council the local authority under it. The Vestry of Chelsea objected to those clauses. They were the authority in the case of the Chelsea Electricity Supply Company, which supplied the electric light to 215 houses in the parish. It might be contended that no objection was offered by the Vestry to the Order of the London Electric Supply Corporation, confirmed by Parliament in 1889, but he would point out that the area covered by that Order extended to nearly the whole of the metropolis, and the parish of Chelsea only formed an integral portion of that area; moreover, the generating station of the London Electric Supply Corporation was situated at Deptford. The undertaking, therefore, could not in any sense be regarded as a local one, and the Vestry recognised the expediency, in that instance, of a metropolitan authority for a metropolitan Order. The Electric Lighting Acts of 1882 and 1888 specified the Vestry as the local authority for all purposes under the Acts, except within the limits expressly assigned to the Metropolitan Board of Works, and the latter Act, which confirmed the definition clause of the earlier one, was passed in the same Session as that in which the County Council was constituted, and, therefore, it was not the intention of Parliament to give control or powers over electric lighting to any other authority than the local authority as defined in those Acts. If the County Council were made the local authority under the Order, a concurrent jurisdiction would be established, which might, and probably would, lead to conflict between the Vestry and the County Council, and by the Order, as it stood, when the Vestry became the undertakers the County Council would exercise an authority over their supply, which should be left to the inhabitants of the district, subject to a reference to the Board of Trade, as it was under the Electric Lighting Acts. Clause 36 of the Order provided that the inspectors should be appointed by the County Council. That provision appeared to be in direct contradiction to the provisions of sub-section (*e*) of section 6 of the Electric Lighting Act of 1882, which, in specifying the regulations to which the undertakers were to be subject, and which, therefore, were the only regulations which the Board of Trade could make in any Order under the Act, expressly provided for the appointment of the inspector of the local authority. Much confusion would also arise from the operation of such a clause, as the following cases would show:—The Cadogan Electric Light Company was a Chelsea company. Their generating station was close to the centre of the parish—in fact, much more so than that of the Chelsea Electricity Supply Company. Both companies were proposing to light King's-road. The Baths Commissioners—who were practically a committee of the Vestry—might take electricity from the Chelsea Electricity Supply Company, and the Vestry might take theirs from the Cadogan Company, and if the lights were bad at the baths the Commissioners might require an electric inspector to test their wires. The Vestry would have power to appoint the inspector, but if their own lights were bad at the Town Hall they would have to ask the County Council to appoint the inspector, as the Vestry would have no power over the Cadogan Company.

The CHAIRMAN: You have no objection to this new power being granted provided that the Vestry are made the local authority?

Mr. HOLLAND: None whatever.

The CHAIRMAN said the Committee desired to hear why a double jurisdiction had been set up in the parish, and whether it was essential.

Mr. CRIPPS, on behalf the London County Council, said the Council were appointed the local authority under the Order of the London Electric Supply Corporation of 1889.

Mr. HOLLAND interposing, said the London Electric Supply Corporation could not in any sense be regarded as a local one. It only supplied the current to two houses within the parish under the control of the Vestry.

The CHAIRMAN said the Committee were unanimously of opinion that, under this Order, the Vestry should be the local authority.

Mr. MUIR MACKENZIE said the promoters had no objection to the amendment.

Mr. CRIPPS said the amendment proposed to be made in this Order would have the effect of altering the existing legislation in regard to electric lighting in every parish in London.

The Bill was amended in accordance with the petition of the Vestry, and ordered to be reported to the House.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *June* 27, 1891.

The Incandescent Lamp Patent Litigation.—It is expected that some decision in the great incandescent lamp case will be reached about the middle of July. The amount of evidence is so enormous—many thousands of printed pages—that it is almost out of the question to expect an early decision, even if the documents were read only in abstract.

The Edison Feeder Patent.—The final evidence is now being taken in the feeder and main patent of the Edison Company. The defendants in this case are really two, both the Thomson-Houston and Westinghouse companies being involved. The case against the latter will probably come up first, however. The feeder and main patent, like the incandescent lamp claim, is one concerning which there may be a good deal of doubt. The prevailing impression seems to be that, of the two, the lamp case is the strongest for the Edison Company.

Aluminium Smelting Dynamo.—A rather interesting dynamo has just been completed in this city for use in aluminium smelting works soon to be erected. It is designed by Mr. T. L. Willson, and is intended for a capacity of 7,000 amperes with potential as high as 110 volts if desired. The weight of the new machine is about 30,000lb., and its armature, a Gramme ring 24in, in diameter and 47in. long, weighs nearly three tons. There is no commutator; the brushes rest directly on the bare bars of copper that form the armature winding. The efficiency has not yet been tested, inasmuch as the machine has not been run under load. The loss from hysteresis, eddy currents, and friction appears to be very small.

The Westinghouse Company.—The affairs of the Westinghouse Company still appear to be somewhat unsettled; the annual meeting, which was to have been held a few months since, was adjourned until the middle of July, owing to the arrangements for transfer of stock being not yet complete.

The Electric Traction Business.—Of the larger electrical companies, the Thomson-Houston seems to be doing the most active business at present. It, and the Westinghouse Company are making considerable inroads in the street car business

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that has been previously held by others, and the Short Company is not behind in this respect. The reason for this may be found in the introduction of slow-speed and gearless motors which have been vigorously exploited during the spring.

Storage Battery Traction.—It is gratifying to record even the temporary success of storage battery traction. During the last winter and spring some six or eight storage battery cars have been in operation in Dubuque, Ia., and recent reports from there are giving most encouraging accounts of the results. The cars of the Electrical Accumulator Company's system are still in the hands of its experts, but they have been running very regularly through a rather severe winter with very few breakdowns, and very little trouble of any kind. The expense, of course, is the unknown factor, but so far as successful service goes they appear to have been doing admirably, and the repairs incurred have, it is said, been far less than were made on a much smaller Edison-Sprague road running under somewhat more severe conditions in the same town. Altogether the Dubuque road appears to afford more encouragement to the friends of storage battery traction than has been accorded it for a considerable time past.

CORRESPONDENCE.

THE NEW RULES FOR THE TECHNOLOGICAL EXAMINATIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your editorial note on page 235 you are good enough to refer to the changes which are to be made henceforth in the examinations in Electric Light and Power conducted for the City and Guilds of London Institute by Mr. Kapp and myself. Whilst thanking you for the terms of commendation in which you speak of the Finsbury Technical College, I would ask you to permit me to point out that these examinations in Electric Light and Power are not confined by any means to the College at Finsbury, but are held at many different centres all over the country, for the students of all the classes in this subject that are taught under the scheme of the City and Guilds' Institute. The new regulations apply to the examinations that will be held in May, 1892.

Will you further permit me to point out that in the "Ordinary" grade there is no longer a separate examination in electrical instrument making; and that in the "Honours" grade the subject is divided into three separate parts, for but one of which a candidate can compete relating, respectively, to put it briefly, to (1) Electrical Measuring Instruments, (2) Dynamos and Motor Construction, (3) Central Station and Contracting Work.—I am, Sir, &c.,

SILVANUS P. THOMPSON.

City and Guilds' Technical College, Finsbury.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to one of the leaderettes in your last issue, it will, doubtless, interest you to know that the system of engineering examination which you advocate, was, I believe, originated, and certainly was used, nearly twenty years ago by my father, Dr. Wm. Anderson, F.R.S., now Director-General of H.M. Ordnance Factories, when he on several occasions conducted examinations at Cooper's Hill Engineering College. As well as I can recollect, he used to set Papers, which the students worked out at home or in their rooms, and they had a week or so allowed to do them in, and were at liberty to use any books or notes that they could get hold of, just as they would do in practical work; in fact, they might do anything short of asking other people to do the work for them, or tell them anything about it. He used also to hold a *viva voce* examination, and I think this and the Papers above mentioned were all that he required to be done.

I believe he found the plan thoroughly satisfactory, and I understand it has been adopted now at University College, London.

I give the above from memory, and may be wrong in some of the minor facts, such as to time allowed for working the Papers, &c., but the principle of it is correct.—I am, Sir, yours, &c.,

E. W. ANDERSON.

3, Whitehall-place, S.W., July 6, 1891.

ELECTRIC RIVETTING PATENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the notes published in your issue of May 29th, under the heading "Electric Rivetting Patents," the statement of the decision by the Examiner of Interferences in the United States Patent Office is given, in which priority of invention was awarded to Mr. E. E. Ries. It may interest you to know that this decision has been reversed on examination into the merits of the case by the Board of Examiners in Chief, and that on every point the ruling has been against Mr. Ries, contrary to the statement which has been hitherto published. The only point that was under dispute in the matter that entered into the case, was concerning my own diligence in working the invention.

The concluding statement of the decision referred to reads as follows:—"Thomson thus has an impregnable record at all points. We are wholly unable to see a case for Mr. Ries, in any aspect. We find Thomson to be the prior inventor, and reverse the decision of the Examiner of Interferences."—I am, Sir, &c.,

ELIHU THOMSON.

Lynn, Mass., June 25, 1891.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

"THE ELECTRICIAN"

ELECTRICAL TRADES' DIRECTORY & HANDBOOK for 1891.

The 1891 edition of our well-known Directory and Handbook is ready, price 5s., postage extra. The book consists of over 900 pages, and has entailed this year a heavy amount of work. The HANDBOOK DIVISION contains a mass of most useful information. The DIRECTORY DIVISION consists of 430 pages, and contains a very carefully compiled Alphabetical and Classified List of Firms and Persons engaged in the Electrical and Allied Trades in all parts of the world. This Division has been corrected up to date, and the book is thoroughly reliable, the very numerous changes which take place at the beginning of the year being incorporated. By the aid of this Directory, makers of Electrical Machinery, Apparatus, Instruments, Fittings, Sundries, Novelties, and other goods, may safely communicate direct with probable customers without the annoyance and great expense consequent upon using books which are mere lists of Members of Scientific Societies repeated again and again. The Colonial and Foreign Division of this Directory will be found extensive and reliable. *Orders should be forwarded at once.*

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TENDERS INVITED.—The London County Council invite tender for making perfect and maintaining in thorough repair for three years the whole of the electric bells and wires, and the apparatus connected therewith, fixed in the land and river stations of the Fire Brigade, and in houses used as lodgings for firemen. Specification, form of tender, and particulars may be obtained on application at the County Hall, Spring-gardens. Tenders, addressed to Mr. H. De la Hooke, clerk of the Council, Spring-gardens, S.W., endorsed "Tender for Maintenance of Electric Bells," to be sent in by noon on Tuesday next, the 14th inst. Persons tendering must have offices and workshops within the County of London.

SALES BY AUCTION.—We would remind our readers of the sales by auction on Tuesday and Wednesday next, by Messrs. Hobson, Richards, and Co., at 36, Albert-embankment, of the valuable plant, machinery, and stock of the Electrical Engineering Corporation (Limited). The machine tools, plant, and stock of the Quintin Matsys Forge, Griffin-street, York-road, S.E., will also be offered for public competition next week, Messrs. Wheatley Kirk, Price, and Goulty being instructed to dispose of the same on Thursday next. Particulars will be found in our advertisements columns.

CHARLESWORTH, HALL AND CO., OLDHAM.— Messrs. John Rankine and Sons, Consulting marine and electrical engineers, Africa

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House, Leadenhall-street, London, and Corporation Quay, North Shields, have been appointed as agents for the Tyne, Wear, and Tees shipbuilding centres by Messrs. Charlesworth, Hall, and Co.

DISSOLUTION OF PARTNERSHIP.—The partnership between Messrs. Urquhart and Bates, electrical engineers, 11, Victoria-street, Westminster, has been dissolved. The business will be carried on by Mr. David Urquhart.

BROWN'S ROTARY ENGINE.—Prof. Jamieson has made a test of this engine, and has given a report on its performance. The report does not, however, give an intelligible account of its construction or action, and we defer publication of it until we are able to describe and illustrate it.

THE "PILSEN" ARC LAMP.—We have received a note from the Pilsen Electric Company in which they state that in their lamp they have succeeded in eliminating all the intricate parts, replacing the same with simple and substantial devices, and that they now claim the lamp to be one of the shortest, lightest, steadiest, safest and cheapest in the world. The Company state that the lamps are now made for direct or alternating currents, for parallel or series burning, and for photographic purposes. We are glad to learn that they are withdrawing the licenses for manufacture under royalty, since a number of very badly made lamps, professing to be of this make, have come under our notice. They intend in future that the lamps shall be made solely by themselves.

COMPANIES' MEETINGS & REPORTS.

The National Telephone Company (Limited).

The eleventh ordinary general meeting of the shareholders of this Company was held at the City Terminus Hotel, Cannon-street, E.C., yesterday (Thursday). Mr. Frederick Richards Leyland presided.

The SECRETARY (Mr. Albert Anns) having read the notice calling the meeting, the CHAIRMAN said: I presume you will take the report and accounts as read, as you have had them in your hands for some days. If so, I propose to go through the report and accounts, and elaborate a little what I have to say. The report has given you the main features of what the transactions of the past year have been. I hope you will consider the results satisfactory, inasmuch as the net revenue account—notwithstanding the heavy reductions that we have made in our rates in the provinces – still leaves us with an increased balance over last year, sufficient to pay the same rate of dividend on a much larger capital, and to carry to reserve fund the same amount as we did last year; and although we carried forward a little less than we did last year, this is, to some extent, accounted for by an item you will see in the net revenue account of £1,388. That amount arises in this way: We last year estimated the dividend to come from the subsidiary companies in which we hold shares at £1,388, and it was so credited in the accounts. Unfortunately, those companies declared no dividend at all, and we were advised, therefore, to put this right in this year's balance-sheet, so that last year got credit for £1,388 which did not belong to it, and this year gets its balance diminished by a corresponding amount in order to set that right. When you take that amount into consideration, which makes in the comparison about £2,800, the difference in what we carry forward this year and what we carried forward last year is a comparatively trifling amount. The next thing I have to remark upon is this: There is a very large amount at the debit of net revenue account, £8,053, "expenses *re* issue of new debenture stock." Well, you all remember perfectly well what the state of the money market was when that issue of £350,000 was made or placed on the market, and, after considering the matter very seriously, we came to the conclusion that it would not have been a wise thing if we had taken the risk of placing the whole of that amount. We thought it was a wiser thing to underwrite a portion of it—£200,000—and to make that, at all events, secure. The cost of that is shown in the accounts. The underwriting, for one thing, is about £7,600, and the rest is for stamps which we were compelled to pay on issuing the debentures. We might have charged that over a number of years, which is a very ordinary practice, but we thought it was a much better thing to put it all to the year, and let each year bear the losses and charges of that year. Then I have to refer to the extension of the Company's business during the year, which is dealt with in the second clause. I have only carried that up to April 30th, the date when these accounts finish, but I may as well tell you that the increase of revenue has gone on since then. The revenue, which, on April 30th, reached £418,560, increased on May 31st to £422,273, and on June 30th to £424,899. You, therefore, see that we are steadily going on with the increase in our rental. The number of subscribers, of course, increased to a corresponding extent. On April 30th the number was 35,440; on May 31st it had increased to 36,131; and on June 30th it rose to 36,655. You see therefore that, notwithstanding the large reductions of rates which we made in the provinces, we have already made up, and more than made up, the loss in our annual rental. Of course, we have had a great deal more work to do for this—more lines to keep in order, more operators to pay, and we have had to make very large additions to our capital expenditure, on which we shall have to pay dividends and interest to our shareholders and debenture holders. The problem, therefore, is still this—How far will this increase go on? Probably by the end of our next year, when I meet you again, I hope (and the figures all point to it) that I shall be able to state that increase has gone on to such an extent as to provide for all the extra expenses, and to make our net revenue and net profit just as good as at present. Of course, it is not my business to prophesy. I can only point out what I think, the figures which I have indicated, and what the probable course of things will be, and then you can judge just as well as I can. There is one thing, by the way, I missed, and you must never forget it. This year's accounts only bear the loss of January, February, March, and April, the first four months of the year. The remaining eight months will fall on next year, and the point is whether the progressive increase will be enough to make up for the loss. The gross rental, it is perfectly clear, will do so; but the next question is—Will the net result do so? With respect to the working expenses, I do not think there is anything I need say beyond what I have said before. In clause 3 we say:—"The number of exchange and private line subscribers over the whole of the Company's system, excluding the South of England district, which last year was 29,257, was on April 30, 1891, 35,440, an increase of 6,183 subscribers during the year, and the number of subscribers is still increasing. The Directors are still acting upon the conviction that it is of vital importance to continue the policy of developing and improving the Company's system, and of giving greater facilities to the public." Last year I spoke at considerable length upon this subject, and told you what we were doing—changing all the shackles into cross arms and insulators, the looping of the junction wires, and the substitution of magneto bells for the ordinary battery bells. We have still gone on with that work. We have done fully one-third of the whole of it, and some of it we have completed altogether. We have still about one-third of that work to do. I think I told you at the time that it would take three years to do it, and we have still the third year's work to do. Of course, you can all understand that the progress, considering that we have to do this work while the ordinary daily service of the Company is going on, must necessarily be slow. It is much more difficult to work under these circumstances than it would be if you had a free hand and a new system to go on with. There is also another disadvantage, namely, that with all the care we take—and the men take every care they can—we cannot avoid contacts between wires when they are working on the roofs of houses. That, of course, brings on us complaints from subscribers, and I can quite understand their complaining bitterly. Till we get the work completed, I am afraid we shall not be able to avoid this. We state in the 5th paragraph: "The Directors have taken over the business of the South of England Telephone Company (Limited), which is now merged in this Company." In all the comparisons I have mentioned I have left out the South of England Company, as it will not be included for the whole year. In the 6th paragraph we say:—"On the amalgamation, in July, 1889, of the three principal companies, it was thought desirable that the customary annual retirement of one-third of the Directors should not take place at the end of the first year, in order that the numerous arrangements rendered necessary by the amalgamation and reorganisation of the Company might not be interfered with. These having been now completed, and two of the provincial companies, the Northern and South of England Telephone Companies having been absorbed, the Directors think they ought all, at this meeting, to place their offices at the disposal of the shareholders, and submit themselves for their approval. They, therefore, now all retire, and being eligible, offer themselves for re-election." I have really very little to say on this subject. I think the report has given you all that has to be told to you on that point. The Directors have been very glad to take this opportunity of placing their positions at your disposal. They have thought it was their duty to do so. They place themselves in your hands with the consciousness of having done all that they could in carrying on a very intricate and responsible business, and we hope that what we have done will meet with your approval. I do not think there is anything more that I have to say, but I shall be glad to answer any question.

A brief discussion followed.

Mr. LEAKE thought the general interest account was very large, and it would appear to represent an average of about £100,000. He thought they were going too fast in their expenditure, and he wished to know how they proposed to find the capital for the extensions advocated.

Mr. HARRIS asked if the Directors had taken into consideration the question of putting the lines in better order. His firm had had two lines, one of which was private, which, however, they had given up for an exchange line, and now they had two exchange lines. They had complained to Mr. Anns, who had answered with every courtesy, and the London Manager appeared to have done, he admitted, all that was in his power to improve matters. He thought that at the present juncture the Company should do all they could to improve the service.

Mr. BLACK asked that the expenses might be given in more detail.

Mr. BIDEN also trusted that the service given by the Company should be improved, and thought it a serious matter that a body of their subscribers had combined together with the view of getting their grievances rectified by the Company. With regard to the amalgamation of the new companies, they stood at £230,000 in the accounts, and 6 per cent. on this amount would be nearly £14,000, whereas the accounts for the present year showed nothing like this increase in their net profits.

The CHAIRMAN: Now, Mr. Leake, I will answer you first. This large amount of general interest account—£4,650—you are quite right about. When we made that issue of £350,000 we were heavily indebted to our bankers. You know the rate of interest at that time was pretty high, and that is the explanation of it. You suggest that we ought to go along rather more slowly.

A SHAREHOLDER: Go ahead as fast as you can.

The CHAIRMAN: I do not think you will find that the meeting agree with the view that we should go more slowly. I take a different view. I may be wrong, and you may be right; but I say that the salvation of the Company is to push on as quickly as you can, and thus cover the ground. I do not think you will find the meeting with you on that point. As to

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the Directors' fees, the amount of the division of them—which is a question also of Mr. Beck—I wrote and gave the information required. There is no wish on my part to keep any information from the shareholders that I think it prudent to give them, and which I can give them without injury to the interests of the Company. As you know perfectly well, by the Articles of Association the Directors' fees are £5,000. They have the power of electing from among their own number an executive committee to attend here every week from Liverpool, Manchester, Glasgow, and other places, and to fix their remuneration. We have fixed the remuneration of the executive at another £5,000, and that makes the total cost £10,000. There were 13 Directors to divide that amongst; most of them had to work very hard. I had to work pretty hard myself, and I put it to you whether you think it is too much; if you think so, you have only to say so. Now, in reply to Mr. Black, I can only tell him what I said in my letter—that to divide all these expenses of management and operators' wages would be giving information which would be very valuable to our opponents, and which I do not think would be of very much use to the shareholders. Then Mr. Harris spoke about the lines, and complaints not being attended to. I have always admitted that there are great complaints, and I have told you this very day—that these complaints cannot cease until we get this system put right. We took over a system which was radically bad, and which had to be thoroughly reorganised. That had to be done while the work was going on. It is like a railway, and Mr. Forbes or anybody else can tell you what difficulties there would be in carrying on work when you had the whole service going on.

Mr. HARRIS said he understood that their line had been put in order.

The CHAIRMAN: Then, in that case, I wish you would come and see me.

Mr. HARRIS said that he could not waste his time in this way.

The CHAIRMAN: I am ready to "waste" my time. If Mr. Harris will come and see me I shall be glad to go into the matter; I might then be able to obtain the information as to whether inspectors or any one on the staff were not doing their duties. I have been asked how we are getting on with Hasties' Committee. We have seen some of the members. It is a committee which has names of very great weight and value upon it. We are trying to arrange a meeting with most of those gentlemen, and we will put the thing clearly before them. It is not want of zeal on our part, but we must do one thing or another; we must either stop the service, which evidently we cannot do, or we must go on and do the best we can while the service is proceeding, and, of course, we are subject to these complaints. We are not going to let that matter slide. Mention was made about the amalgamation of the Northern and South of England Companies. The South of England Company was practically taken over within the last month or six weeks. We shall have to go into that and carefully analyse it, but there is not much profit in it now, neither was there in the old Northern Company. But we have turned that into a profitable thing, and I hope we shall be able to do the same with the South of England Company.

Mr. BIDEN asked whether the Directors would in future state their fees separately in the accounts.

The CHAIRMAN said that he had stated them to the meeting, and he wished to know the object of their putting the amount in the account. He inquired if it were the wish of the meeting that they should do so.

A SHAREHOLDER thought that it was very undesirable to publish such information—an opinion which was received in the room with manifestations of approval.

The CHAIRMAN enquired if any other Shareholder wished to address the meeting, and no one rising to continue the discussion, he proposed the following resolution:—

"*That the Report and Accounts, be taken as read, be received and adopted, and that a dividend be paid for the last half-year at the rate of 6 per cent. per annum, less income-tax, on the amounts paid up on the 1st and 2nd Preference Shares, and at the rate of 7 per cent. per annum, less income-tax, on the amount paid up on the Ordinary shares, making, with the interim dividend already paid, 6 per cent. for the year ending April 30, 1891.*"

Mr. J. S. FORBES: I beg to second the resolution. The Chairman has dealt so exhaustively with the position of the Company and the accounts that he has left me little to say; but I think I must say, by way of supplement, and to enforce what he has said already, about the numerous complaints—well-grounded complaints—which we receive, that they do really arise from circumstances which the Directors cannot govern. You have to remember the awful complications of a city like London, and you have to remember that we have no legal *status*. We are acting on sufferance. Those two facts will at once explain why the service in London is not as satisfactory as it might be; and you cannot reconstruct and carry on a business without great time and trouble in face of difficulties which, in my experience—and it is pretty wide—have never been encountered before. It is well that this should go forth to the public, and that they should understand what is the cause of our difficulties. If they understood the difficulties against which we have to carry on our business the complaints would sometimes, at all events, be less strongly stated. The fact is that people who complain do not understand the difficulty of the work as we do, and no men have ever set themselves more determinately to work to overcome the difficulties than the directors of this Company.

The CHAIRMAN then put the motion in the usual manner, and declared it carried unanimously.

Mr. FORBES then took the Chair.

Mr. F. FAITHFULL BEGG proposed the re-election of Mr. Leyland. He stated that that gentleman had been connected with the Company since the amalgamation, having been previously a Director of the United Company. Since Mr. Leyland became President of the National Company—the amalgamated Company—he had devoted himself day by day, and week by week, to the management of their affairs. He was convinced that the shareholders could not do better than re-elect Mr. Leyland as their President.

Mr. BALFOUR seconded the motion, observing that the best test of the success which had followed the untiring zeal and devotion of Mr. Leyland in the Company's behalf was indicated by the report which the Directors had presented to the shareholders on that occasion.

Mr. FORBES fully endorsed the remarks of Mr. Begg and Mr Balfour, and observed that the Directors, had it been necessary to speak on this subject, would have been justified in speaking in even higher terms of the services which had been rendered by their President. He put the resolution, and it was carried unanimously.

The CHAIRMAN, in acknowledging his re-election, promised to do his utmost in the future to promote the welfare of the Company, as he had done in the past.

Mr. FITZGERALD then proposed the re-election of the Vice-Presidents, Mr. Forbes and Colonel R. Raynsford Jackson. He spoke highly of the services which had been rendered by these gentlemen to the Company, and said he thought the shareholders would agree with him that it was an honour to have two such gentlemen on the Board of the Company.

Mr. W. A. SMITH seconded the motion.

The CHAIRMAN said he concurred to the fullest extent with what had been said regarding the qualities of Mr. Forbes and Colonel Jackson. He put the resolution, and it was carried unanimously.

Mr. RIDSDALE proposed the re-election of the Directors of the Company—Messrs. C. S. Agnew, John Bruce, Peter Garnett, Eli Heyworth, W. C. Quilter, M.P., George H. Robertson, Samuel H. Sands, and Alderman Joseph Thompson. He warmly testified to the services of these gentlemen, and expressed a hope that they would get the West of England Company amalgamated with the National Company. He enquired how the Bill in Parliament for giving the Company statutory powers was going on.

The CHAIRMAN: We are preparing it. It is not to be deposited until the month of November.

A SHAREHOLDER seconded the motion.

The CHAIRMAN put the resolution and declared it carried unanimously. The Chairman afterwards referred to the retirement from the Board of Mr. Batten and Mr. Parrish, and stated that they proposed on the present occasion to fill up one of the vacancies by the appointment of Mr. William Alexander Smith. He then proposed a resolution electing Mr. Smith to a seat ta the Board.

Colonel JACKSON seconded the motion, and stated that Mr. Smith was eminently qualified for the position.

The motion was carried unanimously.

A vote of thanks to the President, Vice-Presidents, and Directors was then proposed and seconded in eulogistic terms, and was carried by acclamation.

The CHAIRMAN acknowledged the compliment, and the proceedings then terminated.

The India Rubber, Gutta Percha, and Telegraph Works Company (Limited).

The half-yearly general meeting of the Company was held on Thursday, at the City Terminus Hotel, Cannon-street, for the purpose of declaring an interim dividend. Mr. S. W. Silver, the Chairman of the Company, presided.

Mr. WILLIAM J. TYLER, the secretary, read the notice convening the meeting.

The CHAIRMAN: Gentlemen, the notice just read contains the object of our meeting, and, in accordance with it, I move that an interim dividend of 5 per cent. be paid forthwith; and I feel fully justified in doing so as the sales during the past year in the general branch of business are in excess of last year, which was the largest in amount of any previous year. And this, I am glad to say, applies also to the foreign factories. When we last met, reference was made to the contract for laying on the Chilian coast of South America 1,700 miles of submarine cable. I have now to report the results to be in all respects satisfactory, notwithstanding the many difficulties arising out of the revolution along the coast where this cable has been laid. The greatest credit is due to the engineer-in-chief, Mr. Hamilton Gray, for the tact and ability displayed in the interests of our Company, and for his good judgment, which has been, I may say, recognised in a substantial way by the English Government. The captain and officers of the vessel "Silvertown" supported him ably, as did the electrical staff. During the last few months the telegraph department has been fairly well employed. On her return from Chili, the steamer "Silvertown" had only time to turn round, refit, and take on board 1,600 miles of submarine cable for the Western and Brazilian Company. She started a fortnight ago, and is now approaching her destination, the east coast of South America. I have no doubt of our being able, at the close of the year, to render satisfactory accounts of our operations, notwithstanding the keen competition that prevails. Now, gentlemen, in thanking you for your attendance here to-day, it merely remains for me to move—

"*That an interim dividend of 5 per cent., or 10s. a share, free of income-tax, be paid on and after the 10th inst.*"

Mr. NEIL BANNATYNE: I beg leave to second that motion.

The motion was put, and carried unanimously.

The CHAIRMAN: Our business, I believe, concludes with that; but perhaps the Managing Director would like to say a few words.

Mr. MATTHEW GRAY, the Managing Director: The Chairman has clearly stated the position of the Company, as far as I can judge. He said the ordinary business of the Company is somewhat better than last year.

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It is very little better, and I am sorry to say that the competition is so great in that part of the business that there is not very much profit attaching to it. I think it is as well to let you know that. I think I may here state that we intend laying a cable between the coast of Africa and Brazil. We have got a concession from the Brazilian Government which enables us to do this. We have started manufacturing the cable, which will keep our mills going for some while.

The CHAIRMAN : Well, gentlemen, that, I think, terminates our business.

Sir WILLIAM WALLACE : I think there is one thing to do before we separate, and that is to vote our thanks to the Chairman and Directors for their management of our business, and I think I may trust that, although we are only making small profits, as Mr. Gray says, we shall probably have a very good dividend when the end of the year comes. And I should like to add to that our thanks to the staff on the steamship "Silvertown," and the rest of the staff of the Company. I am sure the Directors would like that added.

Mr. JOHN OLIVER HANSON : I beg to second that.

The proposition was carried.

The CHAIRMAN : I thank you, Sir William, and gentlemen, for your kind remarks, which will only increase our attention to your interests generally, and make us more earnest ; and as regards the staff, I may say that I am glad you have felt it incumbent to pass that vote, for your thanks to them are thoroughly well deserved.

The meeting then closed.

New Shanghai Electric Company (Limited).

An extraordinary general meeting of the above Company was held at the office on May 20, Mr. J. Beattie in the chair.

The SECRETARY having read the notice calling the meeting,

The CHAIRMAN said :—Gentlemen, the object of the present meeting is to ask you to respond to a call for increased capital, so as to carry out an important proposal for the extension of the Company's business. Although there has been steady and satisfactory progress made during the 2½ years' existence of this Company, the figures of this year so far showing a further marked improvememt, yet it is manifest to the directors, as well as to others well posted on the subject, that anything like full justice cannot be done to the Company without the requisite means to meet all applications. The arc department has not developed much, certainly, though the lighting of the Kinleeyuen wharves is a promising sign, but, pending improvements in the arrangement of the lamps, will make the light more valuable to the community, and may possibly induce the Council to extend the support hitherto given, and so much appreciated by the Company. The success of the incandescent light is so fully recognised in the Shanghai Club, as well as in the hongs where it has been so far installed, that a further unmistakable demand has arisen for it, in some cases from very important quarters ; and as Shanghai is not a poor community, the first cost does not deter many from adopting a good and steady light which does not hurt or vitiate the air :— a too obvious boon in the hot and oppressive weather. In addition to the profit derived from the two systems of lighting, the prospects of future remuneration from the supply of material look promising, as a contract has just been confirmed for the installation of one of the local steamers, and we have to-day been asked for estimates for two others. Under all these circumstances, a capital of some Tls.47,000 is manifestly inadequate, and the Directors hope that, in accordance with the resolution to be brought forward, the present shareholders will subscribe the additional amount to supplement that already promised, so as to complete the Tls.50,000 odd (or most of it) which is required to place the concern on a stronger footing ; for machinery, &c., has to be paid for before any return can be forthcoming, besides which it would doubtless be expedient to purchase the present or more suitable premises. It is true that the shares are at a slight discount, but this can only be because the position and prospects of the Company are so little understood ; for, excepting unforeseen accidents, there is nothing to prevent the payment of a good dividend, after making fair allowance for depreciation of plant. Apart from the question of capital, another impedient has been the difficulty of obtaining Directors versed in the technicalities of electric lighting, but, to obviate this, Messrs. Morrison and Gratton have generously come forward to offer their services as consulting engineers, which practically means the scientific management of the Company's business, an advantage that cannot be questioned for a moment, as very few are similarly qualified to undertake such a post ; and they are prepared to accept a very moderate commission at first, which proves their confidence in its future development. They have carefully gone into all the calculations, every detail at the works being supplied to them, and they are evidently quite satisfied with the result.

Mr. MORRISON having given a very exhaustive account of the present condition of the Company's works and the need for the proposed increase of capital, which he said could not but be beneficial,

The CHAIRMAN then proposed, Mr. HASKELL seconded, and it was carried unanimously :—

"That the Directors be requested to offer the unissued shares of the Company for subscription on the following terms, viz. : That the shares be issued at par. That each shareholder on the register at the date when applications have to be sent in shall receive the full number of shares he applies for, up to the number of shares he holds at that date. That the remaining shares be divided among the other applicants provided that all applications by shareholders be satisfied before any shares are issued to non-shareholders. That the date of application, amounts and dates of payment of instalments, and other terms be fixed by the Directors. That the shares to be issued shall rank with old shares from the date at which they are fully paid up, and in the meantime shall rank for dividend in proportion to the amount paid up on each."

The Direct United States Cable Company (Limited).

The following report of the Directors of this Company for the six months ended June 30 last, to be presented at the twenty-eighth ordinary general meeting of the Company, to be held at Winchester House, Old Broad Street, E.C., on Friday, the 17th inst., at 2 p.m., has been issued :—

The Directors submit the usual statements of account for the half-year ended June 30, 1891, which, with the half-year's accounts to December 31st last, presented at the ordinary general meeting on January 16th last, show the financial result of the fourteenth year's working of the Company.

The half-year's revenue (subject to revision on settlement of the case mentioned below) after deducting out-payments, amounted to £37,352. 19s. 5d. against £40,017. 1s. 0d. for the corresponding period of 1890, being a difference of £2,664. 1s. 7d. against the half-year under review.

The working and other expenses for the same period, including income tax, but exclusive of cost of repairs of cables, amounted to £18,112. 19s. 8d., leaving a balance of £19,239. 19s. 9d. as the net profit of the half-year, making, with £5,510. 11s. 3d. brought forward from the previous half-year, a total of £24,750. 11s. For the corresponding period of 1890 the working expenses and other payments amounted to £17,616. 5s. 8d.

Three quarterly interim dividends of 3s. 6d. each per share, amounting to £31,872. 15s., have been declared and paid during the financial year, and a final payment of 3s. 6d. per share is now proposed, making, with the three interim dividends, 3½ per cent. for the year, being a total distribution of £42,497. The balance of £3,502. 1s. on the revenue account is proposed to be carried forward.

A break in the short section of cable, occasioned by a vessel's anchor, occurred on January 14th, about 278 knots from Halifax, and was repaired on March 28th, at a cost of £2,188. 4s. 8d., which has been debited to the reserve fund account, as heretofore.

In the action of the Anglo-American Company *v.* Paris-New York Telegraph Company, the question referred to the Council of State has been decided in favour of the Anglo Company, the French Company being ordered to pay the costs. The case will now go back to the Court of Appeal.

Pursuant to the provisions of the Articles of Association, two of the Directors, viz. :—Sir John Pender, K.C.M.G., and William Ford, Esq., retire by rotation, and, being eligible, offer themselves for re-election. Mr. John G. Griffiths, F.C.A., and Mr. John Sawyer, F.C.A., the auditors, retire pursuant to the Articles of Association, and offer themselves for re-election.

The Chili Telephone Company, (Limited).

The following is the report of the Directors of this Company for the year ending 31st March last, to be submitted to the shareholders at the meeting, on Tuesday next, at Winchester House, at noon :—

The action in the Chilian court between the Vendor American Company and a small minority of its shareholders, referred to in the fifth paragraph of the last report, was ready for decision, when, by order of the Government, the courts were all closed and they have not since been re-opened ; as, consequently, the impediment to registration of the Company's title has not yet been removed, the business of the Company is continued in the name of the Vendor Company, but without serious damage to this Company's interests.

The purchase of the business of the National Telephone Company of Chili, mentioned in the ninth paragraph of the last report, has been completed, and the business of that Company, so obtained, has been merged in, and has formed a part of, the business of this Company since 1st July, 1890.

After the outbreak of the civil war the business of the Company was stopped by order of the Government, which has since had the entire use of those of our lines situated within the districts remaining under its control ; but business has been resumed for the public at Iquique, and other stations in districts held by the Congress party. On the 31st March, when the present account ended, the public service at Santiago had been suspended for one month and eighteen days. For the loss of business the Government will compensate the Company, and $62,000 had, on the 31st March, been received on account of such compensation.

The Company's property has sustained damage only in the province of Tarapaca. The parts of Iquique and Pisaqua were bombarded, and several battles fought on land. Some of our instruments were destroyed, and some poles and wires cut down ; for this, both parties are held to be directly responsible, as well as for loss of business between January 20th and March 10th, during which period the telephone service there was suspended by order of the authorities.

The outlay on capital account has been large, but it was necessary for the development of the Company's business, which has already increased, and will be still further considerably enlarged when the trunk lines are finished. The general manager directs "special attention to the fact that our construction in Valparaiso and Santiago is practically completed," and adds that "we may confidently expect in the future that the expenditure of the past year will bear good results, and that, when the present troubles are over, the number of subscribers will be largely increased, with very little additional outlay." From some of the expenditure to connect up towns, no revenue has as yet accrued, because the subscribers have not yet been connected.

Part of the outlay has been in connecting the former "National" system with that previously belonging to the Company—for more economical working—and part in supplying heavy fixtures and pole lines, so that, to complete connections for new subscribers, the small cost of running the wires only will be necessary.

The Traiguen district has been opened up, and this is likely to prove very advantageous to the Company. The locality is on the frontier of

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Chili and the Argentine, and is the centre of the corn district. The whole of the country round there has been very rapidly developed, and when the railroad, which is in course of construction, passes through, it is expected that this district will become extremely important. It is intended to connect Concepcion with Victoria, Collipulli, and Angol, and eventually with Chillan; but the necessary money for the building of these lines must be furnished by those subscribers who will be benefited by these connections.

The gross and net revenue of the Company show considerable improvement, and, after all proper deductions are made, the balance available for dividend is equal to 7 per cent. per annum upon the paid-up capital, as against a distribution of 5 per cent. for the previous year.

In view, however, of the continuation of the civil war—with very indefinite prospects of its ending—and also in view of the fact that, for capital purposes, it has been necessary to use, temporarily, the income of the Company until the capital exchequer be replenished by further issue of securities—which cannot be done on satisfactory terms at the present time—the Directors recommend that no dividend be paid, carrying forward, undivided, the whole balance of £14,209 10s. 1d., until peace is re established, and the future of the Company becomes more secure.

The Company is now in sole possession of the whole field. Its system is already in far better order than ever before. It has established new exchanges throughout the country, and its prospects—but for the revolution—are brilliant.

In accordance with the Articles of Association, Colonel R. Raynsford Jackson retires from the board of Directors, and, being eligible, offers himself for re-election. The Auditor, Mr. Thomas A. Welton, also retires, and offers himself for re election.

NEW COMPANIES REGISTERED.

CITY OF WATERFORD ELECTRIC SUPPLY COMPANY (LIMITED).—Registered by H. F. Kite, 11, Queen Victoria-street, E.C., with a capital of £1,000, in £5 shares. The object of this Company is indicated by the title.

COUNTY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—Registered by Sydney Morse, 4, Fenchurch-avenue, E.C., with a capital of £100,000, in £5 shares. Objects: to carry on the business of electricians and electrical engineers in all its branches. The first subscribers are:—

	Shares.
J. A. Kelman, 251, Winchester House, E.C.	1
J. C. Bull, 1 and 2, Great Winchester-street, E.C.	1
E. Garcke, 112, Belvedere-road, Lambeth, S.E.	1
B. H. Van Tromp, 4, Hyde Park-terrace, W.	1
B. Broadhurst, 112, Belvedere-road	1
G. Parker, 20, Bucklersbury	1
T. Cooke, Winchester House	1

There shall be not less than three nor more than seven Directors. The first are the signatories to the memorandum of association. Qualification, one share. Remuneration to be determined in general meeting.

EAST LONDON ELECTRIC SUPPLY COMPANY (LIMITED).—Registered by H. F. Kite, 11, Queen Victoria-street, E.C., with a capital of £1,000, in £5 shares. Object: to carry on the business of an electric supply Company in all its branches.

ETCHELLS BROTHERS (LIMITED).—Registered with a capital of £2,000, in £1 shares. Object: to acquire the undertaking of Etchells Brothers, at St. Nicholas street, Carlisle, and to carry on generally the business of iron and brass founders, pattern makers, mechanical engineers, &c.

FAIR MOUNT SYNDICATE (LIMITED).—Registered with a capital of £80,000, in £10 shares. The objects include the carrying on the business of a telegraphic and telephonic company in their respective branches.

GEORGE NEWNES (LIMITED).—Registered with a capital of £400,000, in £1 shares. The principal object is to acquire the publishing business established by Mr. George Newnes, at Burleigh-street, Strand, London, W.C., and it is proposed, amongst a variety of other objects, to construct and work any telephones, electric works, and any other business, whether manufacturing or otherwise, which may seem to the Company capable of being carried on, conveniently, in connection with the above.

GLASGOW GOLD, SILVER, AND COPPER EXTRACTING SYNDICATE (LIMITED).—Registered in Scotland, with a capital of £30,000, in £1 shares. Object: to acquire and work processes for extracting gold, silver, and copper and other metals from their ores, with patent rights and protections for using the same; to adopt an agreement with A. French, metallurgical chemist, Larbert, and William Stewart, Craigmuir, Leuzie; and to take, hold, and work the patents to be acquired by the Company under such agreement; to search for gold, silver, and copper mines and reefs; to purchase, dress, crush, refine ores, metals, and mineral substances, and generally to carry on metallurgical, chemical, or electrical operations or processes which may be conducive to any of the Company's objects. The offices are at 175, St. Vincent-street, Glasgow, and the secretary is Mr. Thomas French.

HAMPSTEAD ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—Registered by R. McInglis, 5, Victoria-street, S.W., with a capital of £1,000, in £1 shares. The objects of this Company are indicated by the title.

INTERNATIONAL INVENTIONS CORPORATION (LIMITED).—Registered with a capital of £10,000 in £1 shares. Object: to carry on business as bankers and capitalists and also as civil, mechanical, and electrical engineers, &c.

NEW COMPANIES REGISTERED DURING JUNE.—During the month of June new companies were registered in London with a total capital of of £10,265,150, out of which amount electrical undertakings accounted for £231,400, and engineering concerns were responsible for £499,050.

MUSHET'S (LIMITED).—Registered in Scotland with a capital of £30,000, in £5 shares. Object: to carry on the business of iron founding and engineering in Scotland, and of trading in metals; to manufacture products from metals, and to dispose thereof; to acquire the property, assets and business of the Mushet Ironworks in Dalkeith and Granton, and to carry on the same or any extensions thereof. The offices are in St. Andrew-square, Edinburgh, and Mr. John C. Chisholm is the secretary.

ST. JOHN, HAMPSTEAD, ELECTRIC SUPPLY COMPANY (LIMITED).—Registered by H. F. Kite, 11, Queen Victoria-street, E.C., with a capital of £1,000, in £5 shares. The object of this Company is indicated by the title.

SOUTH AMERICAN CABLE COMPANY (LIMITED).—Registered by Wilson, Bristows and Carpmael, 1, Copthall-buildings, E.C., with a capital of £500,000 in £10 shares. The objects of the Company are the establishing, maintaining and working of telegraphs, telegraphic, telephonic, or other communication, as well overland as submarine, from, in, and between South America, Africa, Europe, and islands or places in the Atlantic Ocean, or any of them. The first subscribers are:—

	Shares.
A. Scott, 149, Leadenhall-street, E.C.	1
H. Marsham, 28, Bury-street, St. James's	1
J. W. Silver, Letcount Manor, Wantage	1
R. Henderson, 7, Mincing-lane	1
R. K. Gray, 106, Cannon-street, E.C.	1
M. Gray, Lessness-park, Abbey-wood, Kent	1
A. W. Jarvis, M.P., 120, Mount-street, W.	1

There shall not be less than three nor more than seven directors; the first shall be appointed by the signatories to the Memorandum of Association. Qualification, £500. Remuneration, £1,200 per annum, with a further 5 per cent. on the surplus profits after 6 per cent. dividend, the same to be divisible.

SWAZILAND CONCESSIONS (LIMITED).—Registered with a capital of £300,000, in £1 shares. Object: To acquire the concessions granted to John Thorburn by the late King of Swaziland, South Africa, and to carry on generally the several businesses of miners, mechanical engineers, electricians, &c.

THOMAS MOY (LIMITED).—This Company has been registered with a capital of £100,000, in £50 shares. The principal object is to acquire the business of Thomas Moy, at Colchester, and to carry on the businesses of merchants and dealers in minerals of every description, producers of electricity for any purpose, &c.

WYNDHAM ELECTRIC LIGHT COMPANY (LIMITED).—Registered by Drake, Driver and Leaver, 13, New Bridge-street, E.C., with a capital of £1,500 in £1 shares. Object: The public and private lighting of the village of Blaenrhondda by electricity. Registered without Articles of Association.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the past week amounted to £5,028.

CITY AND SOUTH LONDON RAILWAY COMPANY.—The traffic receipts of this Company for the past week amounted to £719. The aggregate receipts for the half-year ended June 30th amounted to £19,407.

DIRECT SPANISH TELEGRAPH COMPANY.—The traffic receipts of this Company for the month of June, 1891, amounted to £1,882, as against £2,085 in the corresponding period of last year, or a decrease of £203.

EASTERN TELEGRAPH COMPANY.—The Directors of this Company announce that, subject to final audit, the accounts show, after placing about £95,000 to reserve fund, a balance available sufficient to pay at the general meeting on July 16th the fixed dividend of 3s. per share, being at the rate of 6 per cent. per annum on the preference shares, less income-tax; and a final payment of 2s. 6d. per share with a bonus of 3s. per share, both free of income-tax, on the ordinary shares, making, with previous payments on account, a total distribution of 6½ per cent. on those shares for the year ended March 31, 1891. The transfer books of the Company will be closed from the 9th to 16th July, both days inclusive. The traffic receipts of this Company for June were £52,341, as against £51,019 for the same period of 1890, an increase of £1,322.

EASTERN EXTENSION TELEGRAPH COMPANY.—The receipts of this Company for June amounted to £39,749, as against £43,198 in the corresponding period of last year, showing a decrease of £3,449.

EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED).—The eighth ordinary general meeting of this Company will be held at the Westminster Palace Hotel, Victoria-street, S.W., on Tuesday, the 21st inst., when the Directors will recommend a dividend at the rate of 7 per cent. per annum for the six months ended June 30, 1891, making, with the interim dividend paid in February last, 7 per cent. for the year, and a further dividend of 10 per cent. in respect of the arrears of cumulative preferential dividend, to be distributed in accordance with the Articles of Association.

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GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of this Company are as follows:—Receipts in June, 1891, £27,400; 1st January to 30th June, 1891, £141,400; corresponding months, 1890, £130,400; corresponding months, 1889, £129,400.

MONTEVIDEAN AND BRAZILIAN TELEGRAPH COMPANY, LIMITED (IN LIQUIDATION).—A meeting of the shareholders of this Company is to be held at Langthorn House, Copthall-avenue, on August 11th, at 12, to receive the liquidator's account of the winding-up

ST. JAMES'S AND PALL MALL ELECTRIC LIGHTING COMPANY (LIMITED).—The Stock Exchange Committee have appointed Tuesday, July 14th, a special settling day in this Company's ordinary shares, Nos. 101 to 18,780, and preference shares Nos. 20,081 to 30,080, and have ordered these securities to be quoted in the official list.—The electric current sold during the quarter ending June 30th last amounted to £6,632, as against £1,991 for the corresponding period of last year.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY.—The half-yearly general meeting of this Company will be held at the offices, 38, Old Broad-street, E.C., on Tuesday next, the 14th inst., at 1 p.m. The Directors announce a dividend of 12s. per share. Notice is given in our advertisement columns that the transfer books of this Company will be closed from the 6th inst. to the 14th inst., both days inclusive.

WEST AFRICAN TELEGRAPH COMPANY (LIMITED).—Our advertisement columns contain an announcement of the numbers of the Five per Cent. Mortgage Debentures drawn on July 2nd for payment at par on September 1st.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended July 3, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,563.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The receipts of this Company for the half-month to June 15th amounted to £2,491, as compared with £3,186 for the corresponding period last year.

CRICKET.—A match has been arranged, and will be played to-morrow afternoon at Neasden, commencing at 3:30, between the Eastern Telegraph Company and Messrs. Kenneth Anderson and Co., of Throgmorton-avenue, E.C.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, July 1.	Price Wednesday, July 8.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending July 1. Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
£1,300,980	Stock	12/0	Anglo-American	45½ 46½	45 46	..	Jan., Apr., July, Oct.	46½	45¼
£2,849,510	Stock	24/0	Do. Preferred	84 85	84 85	6 15 4	" "	85	84
£2,849,510	Stock	..	Do. Deferred	10¾ 11¼	10¾ 11¼	..	..	11¼	..
£250,000	100	4%	African Direct, Telegraph 4% Debentures ...xd	97 100	98 101	3 19 3	January and July ..	99½	..
130,000	£10	3/0	Brazilian Submarine.....xd	11½ 12	11½ 12	7 1 8	Mar., June, Oct., Dec.	12	11⅝
£69,200	£100	5%	Do. 5 per Cent. Bonds	101 104	101 104	4 16 2	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)..xd	103 107	103 107	4 13 6	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock .....xd	103 107	103 107	6 6 2	April and October ..	106¾	105⅝
16,000	10	8/0	Cuba Submarine	10½ 11½	10½ 11½	6 19 2	February and August	..	..
6,000	10	10%	Do. Preference 10%	17 18	17 18	5 11 1	" "	18	17⅝
12,931	5	3/2½	Direct Spanish (£4 paid)	3⅜ 4¼	3⅜ 4¼	6 11 9	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	10½ 10⅝	10⅝ 10⅞	6 8 8	Jan., Apr., July, Oct.	10⅞	10⅝
400,000	10	2/6	Eastern	14⅝ 14⅞	14¾ 15	4 6 8	" "	14⅞	14⅝
70,000	10	6%	Do. 6 per Cent. Preference	15 15½	15 15½	3 17 5	" "	..	..
£1,200,000	Stock	6%	Do. 4 per Cent. Mort. Debenture Stock.....	106 109	106 109	3 13 5	May and November	107	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	107 110	4 10 11	February & August	108¼	108¼
250,000	10	6/6	Eastern Extension	14⅜ 15½	15 15½	4 11 10	Jan., Apr., July, Oct.	15½	15⅛
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock	105 108	105 108	3 14 1	..	107	106½
£85,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 ..xd	101 104	101 104	4 16 2	January and July ..	103	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900 xd	101 104	101 104	4 14 4	" "	..	..
180,227	10	2/6	Globe Telegraph and Trust	9½ 9⅝	9½ 9⅝	5 5 1	Jan., Apr., July, Oct.	9⅝	9½
180,042	10	6%	Do. 6 per Cent. Preference	15 15½	15 15½	3 18 8	" "	15½	15
150,000	10	8¾% fr 90	Great Northern .....xd	18½ 18⅝	18½ 18⅝	4 12 6	Jan., April, and July	..	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105 108	105 108	4 12 7	March & September	..	..
17,000	25	37/6	Indo-European	39 41	39 41	4 11 6	May and November	40½	39½
38,348	10	5/0	London Platino-Brazilian	6½ 7½	6½ 7½	6 0 0	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106 109	106 109	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's	8 8½	8 8½	4 14 1	April and October..	8½	..
3,381	£100 Cert.	6%	Submarine Cables Trust 6%	114 118	115 120	5 0 0	" "	..	..
15,609	10	4/0	West African Telegraph	8 9	8 9	5 11 1	January and July ..	..	..
£281,400	100	5%	Do. 5 per Cent. Debentures	95 98	95 98	5 2 0	March & September	96½	95
30,000	10	2/0	West Coast of America	3½ 4½	3 4	..	January and July ..	3½	..
£150,000	100	8%	Do. Debentures 8% 1902.....xd	96 101	97 102	7 16 10	June and December	..	..
88,321	10	9d.	West India and Panama	2⅜ 2⅝	2⅜ 2⅝	..	..	2⅜	2⅛
34,563	10	6/0	Do. 6 per Cent. 1st Preference	10 10½	9¾ 10½	5 17 1	May and November	10⅝	..
4,669	10	34/6	Do. 6 per Cent. 2nd Pref.	9 10	9 10	6 0 0	" "	..	..
61,683	15	9/0	Western and Brazilian	11½ 12	11½ 11¾	6 7 10	" "	11⅝	11⅜
30,364	7½	1/6	Do. 5 per Cent. Cumulative Preferred	6⅞ 7	6⅞ 7	5 7 3	—	6⅞	6¾
30,364	7½	7/6	Do. 5 per Cent. Deferred	4½ 5	4½ 5	..	..	..	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103 106	104 107	5 12 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103 106	103 106	5 13 2	" "	107	104½
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	117 122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bond	100 104	100 104	5 15 5	March & September	..	..
			TELEPHONES.						
224,850	14/0	0/4½	Consolidated Telephone Const. & Maintenance...	1⅞ 1⅞	1⅞ 1⅞	7 9 4	May and November	..	..
220,000	£1	4·76	Oriental (11s. paid)	¼ ⅜	1⅛ 1⅛	6 3 11	Yearly	..	..
438,984	5	6%	National	5 5½	4⅞ 5⅛	5 17 1	June and December	5⅛	5
15,000	10	6/0	Do. 6 per Cent. Cumulative 1st Pref.	12½ 12⅝	13 13½	4 8 11	" "	..	..
15,000	10	4/9⅜	Do. 6 per Cent. Cumulative 2nd Pref. (£8pd) ..	12 12½	12½ 12⅝	3 15 4	" "	..	..
350,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd) ..xd	103 105	104 106	4 4 11	..	105¾	104
58,000	5	1/0	United River Plate	2½ 3½	2½ 3½	..	January and July ..	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock .....xd	85 95	85 95	5 5 8	..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
1,000	£50	..	City of London Electric Lighting Shares (£25 pd)..	36 37	36 37	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	4½ 5	4½ 5	..	..	..	..
5,322	£5	..	House to House Electric	4½ 5½	4½ 5½	..	..	..	..
30,000	£5	..	Liverpool Electric Supply (£3 paid)	2⅝ 2¾	2⅝ 2¾	3 13 1	..	..	..
111,000	5	..	London Electric Supply	2 2½	2 2¼	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	9¾ 10¼	9¾ 1⅛	4 7 7	..	10⅛	10
7,730	£5	..	St. James' and Pall Mall	5⅞ 6⅛	6¾ 7	—	..	..	..
..	..	7%	Do. 7% Preference	¾ 1 prem	1½ 1¾	..	..	..	..
42,853	5	..	Westminster Electric Supply (£5 paid)	4¾ 5¼	4¾ 5¼	..	..	5⅛	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	..	Brush Electrical Engineering	2⅝ 2⅝	2⅝ 2⅝	..	..	2⅝	..
69,996	2	1/1	Do. 6 per Cent. Preference	1⅝ 1⅞	1⅝ 1⅞	6 8 0	June and December	1⅞	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	4 5	4 5	7 0 0	January and July ..	..	..
17,139	5	..	Edison and Swan United	.. ..	.. ..	..	—	..	..
45,000	10	6%	Electric Construction	3½ 4½	3½ 4½	..	—	..	..
70,000	2	10/0	Elmore's Patent Copper Depositing	3½ 3¾	3 3½	..	—	3⅝	3⅛
20,000	5	..	Fowler-Waring Cables (£4 paid)	2 3	2 3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works...	19 20	19 20	5 0 0	February & August	19¾	19⅜
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103 105	103 106	4 4 11	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	7½ 8½	7½ 8½	11 15 3	..	..	..
11,334	£10	5/0	Do. Preference	9½ 9¾	9½ 9¾	8 4 1	..	..	..
78,949	5	2/1⅞	Swan United (£3. 10s. paid)	4½ 5	4½ 5	6 19 10	May and November	4 1/16	4½
37,350	12	36/0	Telegraph Construction and Maintenance.....	46 48	45 47	5 5 0	March and July.....	45½	..
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894.....xd	101 104	101 104	4 16 2	January and July ..	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£3 paid)	2⅛ 2⅜	2⅛ 2⅜	..	..	..	..
—	£5	..	Do. Preference (fully paid)	3⅞ 4⅛	3⅞ 4⅛	..	..	..	..
			RAILWAYS.						
50,000	£10	..	City and South London Railway	4 5	4 5	..	..	..	..

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THE ELECTRICIAN:

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NOTES.

We have received the following telegram from our New York correspondent:—

Judge Wallace's decision in the lamp case yesterday (14th inst.) was strongly in favour of Edison. He dismissed the technical objections in a sweeping manner, and held that Edison invented a practical lamp. The decison was, therefore, given on general facts instead of details of evidence, and the evidence as to lack of invention and novelty was neglected. An injunction was granted and accounts were ordered. An appeal will soon be taken, and this injunction will be fought. Success is possible, but improbable.

The London Overhead Wires Act (1891), which received the Royal Assent on the 3rd inst., is but a mild measure in comparison with the Bill originally drafted by the County Council. extracts from which were published in our issue of January 30th. In the course of its passage through the House of Commons Select Committee the clauses relating to subways, charges for registration, and uniformed inspectors, were shed; and in the Bill which finally received the Royal Assent the telephone clause with the peremptory heading, "Electric currents not to be interfered with," was also omitted. The net result is merely that the County Council is empowered to make bye-laws, to be approved of by the Board of Trade, and to be enforced and administered by the Vestries and Local Boards of the Metropolis, with regard to the registration, erection, maintenance, and removal of overhead wires.

We publish this week the first portion of an abstract of a Paper by Prof. Mengarini, of Rome, on "Alternating Current Electrolysis." The chief novel result of these experiments seems to be the proof that a voltameter acts towards alternating currents like an inductive resistance. The continually reversing counter-electromotive force of polarisation acts like the counter-electromotive force of self-induction in an inductive resistance, and imposes a lag in phase on the resulting current. Hence the work taken up in the voltameter is not correctly measured by the product of the currents flowing through the electrolytic cell and the volts at the terminals. Such products give a number in excess of the true work. The ratio of this product to the true watts may be anything from unity to double or more.

This has an important bearing on the practical use of water resistances to take up the energy of alternating currents. Generally speaking, by far the easiest and cheapest way of getting rid of the electrical energy developed by alternators or transformers when under test is to send the current into a rough voltameter, consisting of a couple of lead plates hung in a tub of water. Such a plan was used at Thames Ditton, on Tuesday, in connection with the tests described in our leader, and since these water resistances are employed every day in quantitative tests as a means of absorbing energy, it now becomes a question how far the product of amperes and volts taken at the tub do really give the true watts absorbed. It may be that when working at 2,000 volts the impressed E.M.F. is so much greater than any possible counter E.M.F. of polarisation that the product of amperes and volts is not very different from the true watts. Experiments should be made to find out how far this is the case. Moreover, the effect must depend to a great extent upon the current density at the surface of the plates, and it is noteworthy that in Prof. Mengarini's experiments the number of amperes used per square centimetre of electrode was in all cases far greater than would naturally be employed with ordinary water resistances. Henceforth we cannot take it for granted that the water tub and lead plates are the exact equivalent of an inductionless resistance.

The Professor's experiments, indeed, make it clear that, under certain circumstances, the power in watts absorbed by a liquid resistance cannot be estimated from the product of volts and amperes, but the theory advanced to show that the resistance is inductive is not so convincing, and it is quite conceivable that the arrangement acts like a condenser. It has long been known that a couple of lead plates in water act like a condenser as far as slow charges and discharges are concerned, the capacity of the plates amounting to several microfarads per square centimetre. We are, however, unaware that any experiments on the action of such plates with alternating currents have been previously published.

An important point in connection with the interpretation of Hertz's experiments has been recently brought out by M. Bjerkness in some experimental work described in another column. Some time ago MM. Sarasin and De La Rive showed that the oscillations set up in the resonator corresponded with the natural period of the resonator, rather than with that of the oscillator; and, by taking this fact into account, they were enabled to correct some previous deductions from Hertz's researches, and to show that the velocity with which the electric waves were propagated was the same in wires as in air. M. Bjerkness now accounts for the experimental results by showing that the oscillations in the vibrator die away far more rapidly

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than those in the resonator. It has to be borne in mind that these oscillations all rise and fall in less than a millionth part of a second, while the sparks which start them only occur a few times a second. If, therefore, the oscillations of the vibrator die away before those of the resonator, the latter is left to vibrate like a drum which has been struck once or twice by some vibrator, and the oscillations which persist are accordingly those which are natural to the resonating body. The case would be reversed if the source of the oscillations maintained its power. Thus the membrane of a telephone only gives out the sounds corresponding with the attractions and repulsions of the magnet operated by the current, because, whatever may be the natural period of oscillation of a body, it will, under the prolonged action of a periodic force, vibrate in accordance with the force which is impressed upon it, and any natural oscillations of its own will be suppressed. The observations of M. BJERKNESS are of considerable interest in connection with HERTZ'S experiments; but it still remains to be shown whether the sparking in the resonator occurs before or after the oscillations in the vibrator have practically died away, for in the former case the argument advanced is irrelevant.

IN the early days of engineering, when there was no mechanical science—that is to say, no systematised fund of knowledge accumulated from other people's experience, and when there was but little theory, or overdrafts on experience not yet acquired, it was customary for the millwright to rely on his instinct or his "eye." This guide is not to be despised, even when we have the most solid experience and trustworthy theories; but instinct must sometimes give way before facts. We noticed, at the works of Messrs. WILLANS and ROBINSON, a drawing of a form of bearing which, to the engineering eye, is hideous as an expedient, and is an apparent confession of inability to line up a bearing or to construct a stiff shaft. But this bearing, which may be described as an egg in a napkin ring, was introduced some years ago by one of our leading dynamo builders. It was used on the outer bearing of their machines when mounted on Willans bed plates. Messrs. WILLANS and ROBINSON have made hundreds, and have recommended them to dynamo makers for several years past, and the firm to which we refer have regularly employed it on all their dynamos. To call it a ball and socket is misleading, there is a bit of a ball, but no concave seat; to call it a swivel bearing is an insult to swivels generally; there is no rotation round a pin, though the bearing is skewered in place with a bolt sticking into it. But it is no use maligning it; we understand that these bearings never give any trouble at all; they are therefore perfect, so there is an end of the matter.

Taunton Exhibition.—General Sir J. Lintorn Simmons has consented to open the forthcoming Electrical Exhibition at Taunton.

The Safety of Electricity.—Of the 1,333 deaths due to accidents which occurred in New York in 1890, two, or ·15 per cent., are attributable to electricity.

Thunderstorms.—During the severe thunderstorms of last week, considerable damage was done to property in the East and North of England. In Essex several sheep were killed and some ricks were set on fire. In the North, mills and houses were struck.

The Writing Telegraph.—A test of the writing telegraph was recently made between New York and Chicago, and was fairly successful. A message of 60 words was transmitted without a break.

Transmission of Power at Steyrermuhl.—The 100 H.P. plant for the electric transmission of power, supplied by the Oerlikon Maschinenfabrik, has given such satisfaction that it has been decided to increase its capacity to 460 H.P.

Electric Lighting in London.—An address will be delivered by Mr. R. Percy Sellon on this subject, before the Balloon Society, at St. James's Hall, Piccadilly, on Friday, July 17th, when Mr. Edward Wood, past President of the Institution of Civil Engineers, will preside.

Driving Electric Clocks by Alternating Currents.—According to the *Zeitschrift für Elektrotechnik*, the customers of the Internationale Elektricitäts Gesellschaft, of Vienna, will shortly be able to be supplied with electric clocks. These will consist of small synchronous electric motors, driven from a large clock at the Central Station in Engerth Strasse.

The Sun Lamp.—This arc lamp, better known under the name of *Lampe Soleil*, was remarkable for its steady, soft light, but the marble blocks surrounding the arc dissipated a great deal of heat, and there were many defects in the arrangement. We are glad to hear that Messrs. Woodhouse and Rawson are about to re-introduce it in an improved form.

Chelsea Vestry.—At a recent meeting of this Vestry it was moved:—"That a committee, consisting of 10 members, be appointed to consider and report upon the question of the advisability of erecting a dust destructor, with a view of utilising the refuse for the purpose of generating electricity to be used for the public lighting of the parish."—The motion was carried.

The British Association.—At the forthcoming meeting of the British Association at Cardiff, it is proposed to hold in Section A, if possible in conjunction with Section G, a discussion on "Units and their Nomenclature," having special regard to the new electrical and magnetic units now becoming necessary for practical purposes.

St. Pancras Vestry.—At the meeting of this Vestry, last week, the Electricity Committee reported that they had given consideration to the description of arc lamp columns and lamps required for the public lighting of Tottenham Court-road. Various tenders had been received. The committee had determined to adopt Brockie-Pell lamps, and recommended the purchase of 26 arc lamps and columns.—The report was carried.

Train Lighting Plant.—Referring to the description of the Holmes apparatus which appeared in our issue of May 15th, our attention has been drawn to the fact that the use of two dynamos arranged to give constant E.M.F. over a considerable range of speed has been described in the following patents:—Mordey, No. 342, Jan. 8, 1889; Sayers, No. 3420, Feb. 26, 1889; Holmes, No. 20244, Dec. 17, 1889.

Mutual Telephone Company.—Four hundred and seventy subscribers are now in communication through the Mutual Exchange, and 500 will be joined by July 22nd. By the end of August 700 will be speaking. On July 31st the replacing of the present temporary transmitters by loud-speaking carbon ones will be commenced and finished in about 10 days. The Mutual Loud-Speaking Transmitter has been examined by an eminent firm of solicitors and patent agents, and reported free of all patents owned by the National Telephone Company. On June 30th, the Mutual Company's Manchester system comprised 421 miles of wire.

Electric Transmission of Power at Fribourg.—The municipal authorities of Fribourg are about to instal a hydro-electric transmission of power station at the Sarine dam, outside the town. The contract has been awarded to MM. Cuenod Sautter et Cie, of Geneva, who will instal two 150 H.P. 150 volt machines. Distribution will be effected on the three-wire system. The prices which it is proposed to charge are remarkably low when compared with the tariff elsewhere. Thus the charge for 1 H.P. during a year of 3,000 hours will be 345fr., or 1·15d. per H.P.H. In the case of a 5 H.P. motor, the charge will be 315fr. per H.P. per annum, and 195fr. per H.P. per annum for motors of 21 H.P. and upwards.

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Notices of Application for Provisional Orders.—The following notices of proposed application for Electric Lighting Orders have been served:—Chiselhurst Local Board, the Provincial Electric Lighting Power Supply Company; Newington Vestry, Camberwell and Islington Electric Light and Power Supply Company; Middlesbrough, Middlesbrough Electricity Supply Company; Sheffield, Sheffield Telephone Exchange and Electric Lighting Company, Electric Installation and Maintenance Company; Tunstall, Electric Trust; South Molton (Devon), Devonshire Electric Light and Power Supply Company.

The Thomson Watt-Meter.—A test of the Thomson watt-meter, says the San Francisco correspondent of the *Western Electrician*, was made recently in order to satisfy a customer, who complained of exorbitant bills. It was decided to check the light consumption for 48 consecutive hours, and to do this two men were employed. Their instructions were to make note of the exact time to the second of every lamp which was burned or extinguished, and at the end of the 48 hours their report was found to tally with the watt-meter so nearly as to be regarded as correct. In fact, the watt-meter showed a difference of 30 cents in favour of the consumer, the total bill being considerably in excess of $30.

The French Patent Office System.—In connection with the recent celebration of the centenary of the French patent system, *La Lumière Electrique* remarks that it is not, perhaps, generally known that by statutes dated 1666 and 1669 the Académie des Sciences is charged with giving its opinion upon all inventions, the authors of which demanded privileges. By a Royal decree of 1762 it became theoretically obligatory to send every invention to be examined by the Académie, and the "parlement," to whom letters patent were sent for registration, frequently demanded compliance with this formality. The archives of the Académie contain no less than 10,000 reports on patents, some of which are very curious reading.

Electric Traction at Walsall.—At the last meeting of the Town Council the General Purposes Committee reported that, having had under consideration the report of Mr. F. Brown, of the Walsall Electrical Company, they recommend that, subject to arrangements being made by the Company to the satisfaction of the Committee as to the terms and conditions upon which poles, wires, &c., should be placed in the public streets, the consent of the Council should be given to the Tramway Company working their lines by means of overhead wires, and that the Committee should be authorised to employ an electrician to advise them as to the conditions and terms to be imposed upon the Company. The recommendation of the Committee was carried by 15 votes to 5.

The Electro-deposition of Zinc and Aluminium.—The following recipe for an electrolytic bath is given by Kaselowsky, of Berlin:—

Sulphate of zinc	10 kilogrammes.
Glucose	5 ,,
Water	100 litres.
Sulphate of aluminium	200 grammes.

Weak, but constant currents must be employed, and the strength of the bath must be kept up by the addition of fresh quantities of the soluble salts of zinc and aluminium. Kaselowsky has also obtained good results from a bath composed as follows:—

Chloride of zinc	6 kilogrammes.
Glucose	5 ,,
Water	100 litres.
Chloride of aluminium	350 grammes.

Halle.—We have received from the Allgemeine Elektricitäts Gesellschaft, of Berlin, the following additional particulars with regard to the overhead line at Halle, a/S, to which we referred in our issue of November 14th, 1890. The system comprises three lines, which run through the narrowest streets of the town. There are 20 electric cars in operation, on to which one or more trailers can be coupled when the traffic is large. The length of the tracks is about 4½ miles. Soon after the opening of the lines the Post Office authorities considered it necessary to remove to the house-tops the telephone wires, which had been fixed along some streets on the same route as the electrical leads for the tramway. To avoid any disturbances during the removal of the telephone wires, the commissary of police issued an order to the effect that the trams were to cease running on that particular part until the transference was effected. The work was completed in three days.

The Telephone Clauses in the Electric Lighting Orders.—At the last meeting of the Electrical Trade Section Committee, it will be remembered that the Secretary of the Chamber stated that they had approached the Board of Trade on the question of Telephone Clauses in the Electric Lighting Orders, but the reply was considered so unsatisfactory that the idea of sending an influential deputation was abandoned. We learn now that, although it was not communicated to the Secretary of the Chamber, that the Board of Trade had evidently thought better of it and subsequently altered the Provisional Orders by inserting the clauses for the protection of the Telephone Company, desired by the Chamber of Commerce in lieu of those previously inserted. It is believed that the action of the Chamber has in no small degree contributed to this satisfactory result, and we hope that the same body may now be able to achieve an equally satisfactory result in regard to the overhead wires' question; action in regard to which, we believe, was only delayed in consequence of the unsatisfactory reply already referred to.

Train Lighting at the Cape.—In his report for the year 1890, the General Manager of the Cape Railways states that the electric lighting on the Wynberg line and on the express trains has been a great success, so far as comfort to passengers and immunity from accident are concerned. We have not, he says, had sufficient experience to enable us to gauge the comparative expense of the two systems of lighting hitherto adopted; but electric lighting is certainly more expensive than either colza oil or paraffin lamps. Colza oil gives a wretched light, by which it is impossible to read at night with any degree of comfort. Paraffin gives a brighter light; but although we use the most suitable oil (over 150deg.) there is great risk connected with the burning of this class of oil. Although at first the flame may be very moderate, if great care and attention are not paid to the regulation of the wick, the lamp soon becomes so heated that the soldering is melted, and several accidents have taken place from this cause, at the risk of the passengers' lives and of the safety of the carriages. I recommend, therefore, that electric lighting be adopted throughout the three Systems, and shall make provision on the estimates accordingly.

International Electrical Congress at Frankfort.—It has been decided to hold an International Congress of Electricians at Frankfort, in the second week in September, under the presidency of Dr. von Stephan. The chair at the meetings will be taken by Dr. Werner von Siemens, and a Committee, consisting of the Directors of the Frankfort Electrical Company, Dr. Epstein, Prof. Krebs, Dr. May, Herr Lahmeyer, and other well known engineers, has been appointed. A large number of English and foreign electricians have signified their intention of attending the Congress. Meetings, entertainments, and excursions, extending from the 7th to 13th September have been arranged. Amongst the Papers to be read will probably be the following:—Prof. Carhart, "On Replacing Batteries by Dynamos in Telegraphy"; Prof. Dolbear, "Electrical Terminology"; Herr von Dobrowolsky, "The Transmission of Energy by Means of Alternating Currents"; Dr. Frölich, "The Production and Uses of Ozone"; Dr. Kohlrausch, "The Best Training for an Electrical Engineer"; Dr. May, "Lighting Regulations from the Point of View of the Fire Insurance Companies." The Papers and discussions are to be printed in book form, and issued to the members shortly after the termination of the Congress. Tickets, which include a certain number of admissions to the Exhibition, may be had for the sum of 16s., and any further information can be obtained from the Frankfort Electrical Company.

Carlow.—On Monday last, influential deputations of Irish Municipal Authorities were invited by Messrs. J. E. H. Gordon and Co. to view the works which have been established at Milford, near Carlow, for utilising the waters of the river Barrow for the electric lighting of the city. The visitors were shown over the works (which are situated on the ground floor of a large unused mill) by Mr. Gordon, Mr. Rivington, and Mr.

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Meredith (the engineer in charge of the installation), and they were evidently impressed with the success of Messrs. Gordon's scheme. In the evening a dinner was given in the Town Hall to about sixty of the leading citizens of Carlow and the deputations referred to above, the chair being taken by Mr. Gordon, who was supported, amongst others, by Mr. Hammond, the newly-elected member for Carlow, who has also been for twelve years chairman of the Town Commissioners. It is mainly through Mr. Hammond's efforts that the Local Authority has been induced to give Messrs. Gordon their cordial support. Members of several of the deputations present notified that they had been instructed to prepare reports for the bodies who had sent them, and agreed that what they had seen had given them hope that at no distant time their respective towns would be lighted by electricity. The installation, so far as it goes, is a decided success, although the guests at the dinner had a practical demonstration of the disadvantages attendant upon temporary work, as towards the close of the function the large dining-room was left in darkness. The town lighting was in no way affected.

The Chicago Exhibition.—The decision of the English Government to take part officially in the great Exhibition which will be held in Chicago in 1893 was notified, says *The Times*, to the Government of the United States some three or four months ago, and we are now able to announce that the necessary arrangements have been completed. The Council of the Society of Arts will be appointed a Royal Commission for the purpose of superintending and directing the formation of the British Section, and will receive a grant of £25,000 towards the expenses which will be incurred. This grant is less than any previous one which has been made for a similar purpose, that for Paris in 1857 having been £126,000; that for Paris in 1878, £67,000; that for Philadelphia in 1876, £40,000; and that for Vienna, £28,000. The willingness of the Council of the Society of Arts to accept a comparatively small sum is due to the experience gained at the Paris Exhibition of 1889, when no grant at all was made by the Government, and the expenses of the British Section were defrayed by the exhibitors themselves, aided by contributions obtained by the Mansion House Committee. Sir Henry Trueman Wood, the Secretary of the Society of Arts, filled the office of Secretary to the British Section on that occasion; and the results then obtained convinced him, and have enabled him to convince the Council of the Society, that the Government contribution will be supplemented to any necessary extent. The authorities at Chicago will allot space to the British Commission without charge, and a certain rent will be paid by every exhibitor. This source of income alone, it is believed, will be sufficient to bring up the £25,000 to the full amount which will be required for the expenditure of the Commission.

Indian Telegraph Statistics.—During the year 1889-90 the Indian telegraph system was increased by 6,470 miles of wire, or 6 per cent., the total being now nearly 106,000 miles, Military operations in Upper Burmah necessitated the erection of some 370 miles of line, most of the work being carried out under the most trying conditions. The total number of interruptions during 1889-90 amounted to 1840, lasting in all 34,409 hours, as against 1,903 and 38,729 respectively for the previous year. Of these 1,840 interruptions, 222, or 12 per cent. were due to storms; 59, or 3 per cent., to floods; 42, or 2·3 per cent., to lightning; 440, or 24 per cent., to birds, animals, and falling trees; and 148, or 8 per cent., to "*malice prepense.*" The interruptions due to floods, although comparatively few in number, were serious as to duration, amounting to 2,483 hours, or over 7 per cent. of the total. The number of telegraph offices open to the public is now 2,935, as against 2,740 in the previous year, increase 7 per cent. The total number of telegrams transmitted during 1889-90, including Government and international messages, amounted to 3,132,571, as against 2,982,152 for the preceding twelve months, an increase of 5 per cent. Government messages, inland and international, amounted to 16 per cent. of the total number transmitted, and their productive value to 20 per cent. of the total value. The general tendency is for the numerical percentage of Government messages to slightly increase, and for their average length to rapidly diminish. Inland telegrams, which form 70 per cent. of the total, only increased by 2·58 per cent. in number, and by 2·1 per cent. in value, in 1889-90. The custom of sending "deferred" telegrams tends to increase, nearly half of the private telegrams now being in this category. Nearly 72,000 telegraphic money orders were despatched during 1889-90, the increase over the preceding year amounting to 22 per cent.

Balata.—An exhaustive report on balata, or chicle gum, has recently been drawn up by Mr. G. S. Jenman, Government Botanist and Superintendent of the Botanic Gardens in British Guiana. The bullet-tree, from the bark of which balata is obtained, is a large forest tree ranging from Jamaica and Trinidad to Venezuela and Guiana. The tree grows to a height of 120ft., and has a large, spreading head. The trunk is nearly cylindrical. The bark is about ½in. thick, with deep parallel fissures, an inch or so apart. The hard, reddish-coloured wood is one of the densest in the colony, and is used for all sorts of purposes where great strength and durability are required. Dr. Hugo Müller, in a report on the substance, says:—"It seems that balata is by no means neglected, and, in fact, it would find ready purchasers if more of it came to the market. It commands a higher price than gutta-percha. It is used in almost all cases in which gutta-percha is used, but, on account of its higher price, only for superior purposes. It seems that balata is treated by the manufacturers simply as a superior kind of gutta-percha, and, therefore, its name disappears when manufactured. Nevertheless, balata is distinctly different from gutta-percha, and this is especially manifested in some of its physical characters. For instance, it is somewhat softer at ordinary temperatures, and not so rigid in the cold. In one respect balata shows a very marked and important difference from gutta-percha, and that is its behaviour under the influence of the atmosphere; while gutta-percha, when exposed to light and air, soon becomes altered on the surface, and changed into a brittle resinous substance into which the whole of the mass is gradually converted in the course of time, balata, on the other hand, is but slowly acted upon under these circumstances. The electrical insulating quality of balata is said to be quite equal to that of gutta-percha." The price for pure milk is 4s. per gallon, or occasionally a dollar, and for clean, well dried balata, 1s. per pound. The yield of a tree varies according to circumstances. If favourable, a tree 15in. to 20in. in diameter, bled 8ft. high, will yield three pints of milk.

The Electrical Engineering Department of Cornell University.—At the time of its erection in 1883, Franklin Hall (Cornell University) says the *Electrical Engineer* of New York, which was designed as a physical and chemical laboratory combined, was deemed ample for the accommodation of both departments. At the present time, however, the entire building is given over to the study of experimental physics. Research is regarded as a very important feature of the work of the department, and it forms an essential element in the training of all advanced students in physics. Such students come to it well equipped after a year of lectures and recitations, a year in the junior laboratories, and a year of more difficult work in heat and applied electricity. At the head of the department is Prof. E. L. Nichols. The dynamos that are used for University lighting are arranged to be operated with the greatest economy, as well as to afford opportunity for complete "plant" testing by students of electrical engineering. They have been placed in the steam engine laboratory in the closest proximity to the sources of water and steam power. The dynamos are so installed that they may be driven by water or steam power, or both. Ordinarily they are operated by water power, furnished by the turbine water wheel in the Ithaca Gorge. The dynamo room, which is in charge of Prof. H. J Ryan, is believed to be the largest college dynamo room in the United States, if not in the world. It contains no machines that are used in regular lighting service, but is devoted entirely to the experimental study of dynamos and motors. The floor space is 40ft. by 70ft. The collection includes nearly all the well-known commercial types, together with many machines of unusual form, constructed especially for experimental purposes. These machines are of various sizes, from 20 H.P. down, and they are arranged with special reference to the requirements of

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experimental work. The measurement of current and electromotive force, together with a detailed study of storage batteries, arc lamps, voltmeters and electric meters, is carried on in a substantial one-storey building 100ft. by 37ft. Operations of extreme precision are conducted in the Magnetic Observatory, an isolated building entirely free from iron, which contains the great galvanometer and other standard instruments for measuring current and potential, and the magnetic elements.

Test of the Power Plant of the Utica (N.Y.) Electrical Belt Line Railway.—This company, says Messrs. O. G. Heilman and H. B. Clarke in the Cornell *Crank*, operates 26 miles of road. The power station is situated outside the city limits, at a distance of about two miles from the business centre. The steam plant consists of three 200 H.P. Armington and Sims cross compound engines. In the generation of electricity, six Thomson-Houston dynamos are in use, two being driven from each engine. Two runs were made, a preliminary run on May 2nd of five hours' duration, and the main test on the following day of 10 hours, readings being taken from 9 a.m. until 7 p.m. The feed water was measured by means of two calibrated barrels, one being filled while the other was emptying, and then reversing the process. Although the quantity of water required was large, by the use of this method no difficulty was experienced in keeping the supply equal to the demand. The injection water for the condenser was drawn from a pond near by, and after passing through the system was again returned to the pond through a sluice of rectangular section. The quantity of flow was obtained by placing a weir in the sluice, and the height of flow over the weir was measured by a hook gauge. The weight of coal consumed was determined in the usual manner, a Fairbanks scale being placed in the boiler room, and loads of 200 pounds each were dumped in front of the boiler at a time. The ash pits were cleared at the end of the test, and the ashes placed in the barrow and weighed. Electrical readings of current and voltage were taken every five minutes during the test. Below are tabulated some of the more important results.

Duration of test	10 hours.
Fuel burned	7,000 pounds.
Total ash	988 ,,
Moisture in 100lb.	8 ,,
Weight of combustible	5,452 ,,
Efficiency of combustion	82·15 per cent.
Kind of coal.	One-third bit slack and two-thirds anthracite culm.
Fuel per square foot of grate per hour	11·60 pounds.
Combustible per square foot grate per hour	9·087 ,,
Total water supplied	49,355·4 ,,
Average steam pressure (absolute)	138·8 ,,
Revolutions of engine	261
Average indicated horse-power	190 53
Coal per indicated horse-power per hour	3·5 pounds.
Water per indicated horse-power per hour (without charging condenser)	21·72 pounds.

$$\text{Average efficiency} = \frac{\text{Average electrical horse power}}{\text{Average indicator horse power}} = 81 \text{ per cent.}$$

Electric Lighting in Chicago.—A recent issue of *Engineering* contains a brief account of the rise and progress of municipal electric lighting in Chicago. In 1883 the Common Council of the city passed an ordinance requiring all electric conductors to be placed underground; the various companies doing business in the city, after exhausting all means to evade the ordinance, adopted various systems for placing their wires underground, viz., Dorsett conduit, Johnstone conduit, iron pipe, wooden boxes in which cable was placed, and the space between the box and cable filled with bituminous concrete; also conduits of creosoted wood and vitrified sewer pipe. Up to date these companies have placed underground 75 miles of conduit and about 7,000 miles of wire; the wire so placed underground embraces all branches of service, viz., telegraph, telephone, police, fire alarm, electric lighting, &c. In 1887 the city of Chicago erected 105 arc lamps of 2,000 c.p. on the bridges, viaducts, and street ends abutting the Chicago River. In 1889 it was decided to light the entire city by electric light, and to this end the city was divided into 12 electric light districts; each district was to have a power station located as near the centre as possible. In accordance with this plan power stations have been built in four districts. They are designed to accommodate the machinery necessary to operate 1,000 arc lights. The engines used are all of 125 H.P. The dynamos vary in capacity from 30 to 60 lights; they are belted direct to the engines. The conduits are of various construction, and include iron pipe laid in earth without other protection; iron pipe laid in concrete; iron pipe laid under the sidewalk space against the area wall; iron pipe, cement lined, laid in concrete. Five different sizes and manufacture of cable are used—viz., Patterson, Cobb vulcanite, standard underground, okonite, and kerite. The three former are lead cased, the latter two are taped. In contracting for the electric light cables a guarantee was required that the insulation resistance should not be less than 500 megohms per mile, and that they should not materially deteriorate for the space of two years after being in service. The electric light post used consists of a hollow iron base extending from the sidewalk to a height of 7ft. A hollow wooden pole extends through the iron base to a height of 9ft. above the base. The hollow space between the iron and wooden pole offers a receptacle not only for an electric light switch and fire-alarm box, where the latter is needed, but if in the future the city should need incandescent lights for city or private use there is room for a converter. The city of Chicago is now operating 929 arc lamps of 2,000 c.p. for illuminating its streets. Its electric light underground system comprises 169 miles of electric light cable.

Rope Driving.—In a Paper read at the Richmond Meeting of the American Society of Mechanical Engineers, Mr. C. W. Hunt says:—"The transmission of power by cotton or manilla ropes was a few years ago an experiment. It passed the experimental stage, and its use has spread with remarkable rapidity both in England and the United States, and promises, at the present rate of increase, to become a formidable competitor with gearing and leather belting for use where the amount of power is large or the distance between the power and the work is comparatively great. In many of the early applications so great a strain was put upon the rope that the wear was rapid. Installations which have been successful, as well as those in which the wear of the rope was destructive, indicate that 200lb. on a rope 1in. in diameter is a safe and economical working load. This makes the normal working load equal to one-thirty-sixth of the breaking strength and about one-twenty-fifth of the strength at the splice. The actual loads are ordinarily much greater, owing to the vibrations in running, as well as from imperfectly adjusted tension mechanism. At a speed of about 80ft. per second the centrifugal force increases faster than the power from increased velocity of the rope, and about 140ft. per second equals the assumed allowable tension of the rope. Computing this force at various speeds and then subtracting it from the assumed maximum tension, we have the force available for the transmission of power. The whole of this force cannot be used, because a certain amount of tension on the slack side of the rope is needed to give adhesion to the pulley. What tension should be given to the rope for this purpose is uncertain, as there are no experiments which give accurate data, and at the present time a decision must be made partly from analogy and partly from experience. The first cost of the rope will be smallest when the power transmitted by it is greatest, and, under the assumed conditions, will be a minimum for a given power when the velocity of the rope is about 80ft. per second. The ratio of the first cost of the rope running at any other speed will be—

$$\text{Ratio of first cost} = \frac{\text{H.P. at 80ft. per second}}{\text{H.P. at required speed}}.$$

The wear of the rope is both internal and external; the internal is caused by the movement of the fibres on each other, under pressure in bending over the sheaves, and the external is caused by the slipping and the wedging in the grooves of the pulley. Both of these causes of wear are, within the limits of ordinary practice, assumed to be directly proportional to the speed. If we divide the value for wear at a given speed by the horse-power that the same rope will transmit at other speeds, we get the relative wear of the rope in transmitting 1 H.P. The higher the speed, up to about 80ft. per second, the more power will be transmitted, but it is accompanied by a more than equivalent wear."

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ELECTROMAGNETIC THEORY.—XII.

BY OLIVER HEAVISIDE.

(*Continued from page 240.*)

§ 69. Passing to more practical and specialised forms of expression of the continuity of energy, it is to be observed first that we are not usually concerned with a resultant flux of energy from all causes, but only of the particular forms relating to the dynamical question that may be under consideration. Secondly, that it is convenient to divide the energy above denoted by T into different parts, denoting potential energy, and kinetic energy, and wasted energy. Thus we have the following as a practical form,

$$\mathbf{fq} + \text{conv}\,[\mathbf{A} + \mathbf{q}(U + T)] = Q + \dot{U} + \dot{T}, \quad . \quad (11)$$

where the terms in the square brackets indicate the energy flux, partly convective, with the factor $\mathbf{q}$, U being the density of potential energy, and T that of kinetic energy, and partly non-convective, viz., $\mathbf{A}$, which may be due to a working stress. Also $\mathbf{fq}$ is the activity of impressed force (here merely a translational force). Thus on the left side of equation (11) we have a statement of the supply of energy to the unit volume fixed in space. On the right side we account for it by the rates of increase of the stored potential and kinetic energy, and by Q, which means the rate of waste of energy in the unit volume. It is also stored, at least temporarily but not recoverably, so that we may ignore energy altogether after it is once wasted.

In place of the term $\mathbf{fq}$, in which the impressed force is translational, we may have other terms possessing a similar meaning, indicating a supply of energy from certain sources. These sources, too, may be not external, but internal or intrinsic, as for instance when there is a thermo-electric or voltaic source of energy within the unit volume considered.

Also, the terms $\mathbf{A}$, U, T, and Q may have to be split up into different parts, according to the nature of the dynamical connections. The important thing to be grasped is, that whenever we definitely localise energy we can obtain an equation showing its continuity in space and time, and that when we can only partially localise it, we can still, by proper devices, allow for the absence of definiteness. The equation is simply the equation of activity of the dynamical system, suitably arranged to show the flux of energy, and can always be obtained when the equations of motion are known and also the nature of the stored and wasted energies.

§ 70. Now, in the electromagnetic case, the "equations of motion" are the two circuital laws, and to form the equation of activity, we may multiply (1) by $(\mathbf{H} - \mathbf{h}_0 - \mathbf{h})$ and (2) by $\mathbf{E} - \mathbf{e}_0 - \mathbf{e})$ and add the results; or else multiply (3) by $(\mathbf{H} - \mathbf{h}_0)$ and (4) by $(\mathbf{E} - \mathbf{e}_0)$ and add the results. The equation of activity thus obtained has then to be dynamically interpreted in accordance with the principle of continuity of energy.

When the medium is stationary, there is no difficulty with the interpretation. We obtain,

$$\mathbf{e}_0\mathbf{J} + \mathbf{h}_0\mathbf{G} = Q + \dot{U} + \dot{T} + \text{div}\,\mathbf{W}, \quad . \quad . \quad . \quad (12)$$

where $\mathbf{W}$ is a new vector given by

$$\mathbf{W} = V(\mathbf{E} - \mathbf{e}_0)(\mathbf{H} - \mathbf{h}_0), \quad . \quad . \quad . \quad . \quad (13)$$

and U is the electric energy, T the magnetic energy, and Q the waste per unit volume.

On the left side of (12) is exhibited the rate of supply of energy from intrinsic sources. On the right side it is accounted for partly by the waste Q, and by increase of the stored energy U and T. The rest is exhibited as the divergence of the flux $\mathbf{W}$ given by (13). We conclude, therefore, that $\mathbf{W}$ expresses the flux of energy in the electromagnetic field when it is stationary.

This remarkable formula was first discovered and interpreted by Prof. Poynting [*Phil. Trans.*, 1884, Pt. 2], and independently by myself a little later. It was this discovery that brought the principle of continuity of energy into prominence. But it should be remembered that there is nothing peculiarly electromagnetic about a flux of energy. It is here made distinct, because the energy is distinctly localised in Maxwell's theory.

The flux of energy takes place in the direction perpendicular to the plane containing the electric and magnetic forces (of the field), say

$$\mathbf{W} = V\mathbf{E}_1\mathbf{H}_1, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

if $\mathbf{E} = \mathbf{e}_0 + \mathbf{E}_1$; $\mathbf{H} = \mathbf{h}_0 + \mathbf{H}_1$.

The formula is not a working formula, in general, for to know $\mathbf{W}$ we must first know the distribution of the electric and magnetic forces. But it is a valuable and instructive formula for all that. Its discovery furnished the first *proof* that Maxwell's theory implied that the insulating medium outside a conducting wire supporting an electric current was the medium through which energy is transferred from its source at a distance, provided that we admit the postulated storage of energy. For inside a wire the electric force is axial, and the magnetic force circular about the axis; the flux of energy is therefore radial. When the current is steady, it comes from the boundary of the wire, and ceases at its axis. It delivers up energy on the way, which is wasted in the Joule-heating. But when the current is not steady, the magnetic and electric energy will be also varying.

If we work out the distributions of electric and magnetic force outside the wire, according to the conditions to which it is subjected and its environment, we can similarly fully trace how the energy is supplied to the wire from its source. It is passed out from the source into the dielectric medium, and then converges upon the wire where it is wasted. The flux of energy usually takes place nearly parallel to the wire (because the electric force is nearly perpendicular to its boundary); its slight slope towards the wire indicates its convergence thereupon. If the wire had no resistance, there would be no convergence of energy upon it, the flux of energy would be quite parallel to it. Details are best studied in the concrete application, and it is only by the consideration of variable states, and the propagation of electromagnetic waves, that we can obtain a full understanding of the meaning of $\mathbf{W}$ considered as a flux of energy.

In the case of a simple progressive plane wave disturbance, in which a distribution of $\mathbf{E}$ and $\mathbf{H}$ (mutually perpendicular) in the plane of the wave is propagated unchanged through a medium at constant speed, it is a self-evident result that the energy of the disturbance travels with it. The flux of energy is, therefore (since $\mathbf{e}_0 = 0$, $\mathbf{h}_0 = 0$),

$$\mathbf{W} = \mathbf{v}\,(U + T) = V\mathbf{E}\mathbf{H}, \quad . \quad . \quad . \quad . \quad (15)$$

where $\mathbf{v}$ is the velocity of the wave, and U, T are the densities (which are here equal) of the electric and magnetic energies. In this example, which is approximately that of radiant energy from the sun, the idea of a flux of energy, and the conclusion that its proper measure is the density of the energy multiplied by the wave velocity, are perfectly plain and reasonable. Now, many cases of the propagation of waves along wires can be reduced to this simple case, with a correction for the resistance of the wire, and other cases can be represented by two or more oppositely travelling plane disturbances. In a very complex electromagnetic field, the flux of energy is necessarily also very complex, and hard to follow; but the fundamental principles concerned are the same throughout.

The flux of energy $\mathbf{W}$ arises from the internal structure of the ether. It is somewhat analogous to the activity of a stress. But the only dynamical analogy that is satisfactory in this respect is that furnished by Sir W. Thomson's rotational ether, when interpreted in a certain manner, so that $2\mathbf{E}$ shall represent a torque, and $\mathbf{H}$ the velocity of the medium, with the result that (on this understanding) $V\mathbf{E}\mathbf{H}$ is the flux of energy, whilst U is the potential energy of the rotation, and T the kinetic translational energy. But it is very difficult to extend this analogy to include electromagnetic phenomena more comprehensively. [*See* Appendix at the end of this chapter.]

§ 71. Passing now to the case of a moving medium, we shall obtain, from equations (1), (2), § 66, the equation of activity,

$$(\mathbf{e}_0 + \mathbf{e})\mathbf{J} + (\mathbf{h}_0 + \mathbf{h})\mathbf{G} = \mathbf{E}\mathbf{J} + \mathbf{H}\mathbf{G} + \text{div}\,V(\mathbf{E} - \mathbf{e}_0 - \mathbf{e})(\mathbf{H} - \mathbf{h}_0 - \mathbf{h}). \quad (16)$$

Or from equations (3), (4), § 66, we may get the form

$$\mathbf{e}_0\mathbf{J}_0 + \mathbf{h}_0\mathbf{G}_0 = \mathbf{E}\mathbf{J}_0 + \mathbf{H}\mathbf{G}_0 + \text{div}\,V(\mathbf{E} - \mathbf{e}_0)(\mathbf{H} - \mathbf{h}_0), \quad (17)$$

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and from these a variety of other forms may be derived. The dynamical interpretation in accordance with the principle of continuity of energy is not so easy as in the former case. I have recently given a full discussion of these equations in another place. The following gives an outline of the results.

Since there is a flux of energy when the medium is stationary, there will still be a flux of this kind (*i.e.*, independent of the motion) when it is moving, whatever other flux of energy there may then be. I conclude that the Poynting flux **W** still preserves the form

$$\mathbf{W} = \mathrm{V}(\mathbf{E} - \mathbf{e}_0)(\mathbf{H} - \mathbf{h}_0), \quad . \quad . \quad . \quad . \quad (18)$$

from the fact that disturbances are propagated through a medium endowed with a uniform translational motion in the same manner as when it is at rest. Otherwise we could only know that it must reduce to this form when at rest.

Next, there is the convective flux of energy

$$\mathbf{q}(\mathrm{U} + \mathrm{T}), \quad . \quad . \quad . \quad . \quad . \quad . \quad (19)$$

where **q** is the velocity of the medium.

Thirdly, there is a flux of energy representing the activity, **A**, of the electromagnetic stress. It is given by

$$\mathbf{A} = -[\mathrm{V}\mathbf{e}\mathbf{H} + \mathrm{V}\mathbf{E}\mathbf{h} + \mathbf{q}(\mathrm{U} + \mathrm{T}]. \quad . \quad . \quad (20)$$

Fourthly, there is, in association with this stress, a convective flux of other energy, say,

$$\mathbf{q}(\mathrm{U}_0 + \mathrm{T}_0). \quad . \quad . \quad . \quad . \quad . \quad . \quad (21)$$

The complete flux of energy is the sum **X**, of these four vectors, *i.e.* :—

$$\mathbf{X} = \mathbf{W} + \mathbf{q}(\mathrm{U} + \mathrm{T}) + \mathbf{A} + \mathbf{q}(\mathrm{U}_0 + \mathrm{T}_0), \quad . \quad . \quad (22)$$

W and **A** being given by (18) and (20).

Finally, the activity of the intrinsic forces is

$$\mathbf{e}_0\mathbf{J}_0 + \mathbf{h}_0\mathbf{G}_0, \quad . \quad . \quad . \quad . \quad . \quad (23)$$

so that $\mathbf{J}_0$ is the true electric current.

We, therefore, have the equation of activity brought to the standard form

$$\mathbf{e}_0\mathbf{J}_0 + \mathbf{h}_0\mathbf{G}_0 = (\mathrm{Q} + \dot{\mathrm{U}} + \dot{\mathrm{T}}) + (\mathrm{Q}_0 + \dot{\mathrm{U}}_0 + \dot{\mathrm{T}}_0) + \mathrm{div.}\,\mathbf{X}, \quad (24)$$

which is a special form of equation (11), with the convergence of the energy flux in it replaced by its divergence (the negative of convergence) on the other side of the equation.

But the unknown terms, on the right side of (24), with the zero suffix, may be entirely eliminated, including those in **X**, by making use of the secondary equation of translational activity

$$\mathbf{F}\mathbf{q} = \mathrm{Q}_0 + \dot{\mathrm{U}}_0 + \dot{\mathrm{T}}_0 + \mathrm{div.}\,\mathbf{q}(\mathrm{U}_0 + \mathrm{T}_0), \quad . \quad . \quad (25)$$

where **F** is the translational force due to the stress.

When this in done, equation (24) takes the form

$$\mathbf{e}_0\mathbf{J}_0 + \mathbf{h}_0\mathbf{G}_0 = \mathrm{Q} + \dot{\mathrm{U}} + \dot{\mathrm{T}} + \mathbf{F}\mathbf{q} + \mathrm{div.}[\mathbf{W} + \mathbf{A} + \mathbf{q}(\mathrm{U} + \mathrm{T})] \quad (26)$$

where the energy flux represented includes the Poynting flux, the stress flux, and the convective flux of electric and magnetic energy.

We may observe that in the expression (20) for **A** occurs the term $-\mathbf{q}(\mathrm{U} + \mathrm{T})$, so that this term may be eliminated from (26), making the energy flux in it become

$$\mathrm{V}(\mathbf{E} - \mathbf{e}_0)(\mathbf{H} - \mathbf{h}_0) - \mathrm{V}\mathbf{e}\mathbf{H} - \mathrm{V}\mathbf{E}\mathbf{h}, \quad . \quad (27)$$

But these changes, with a view to the simplification of expression, cause us to altogether lose sight of the dynamical significance of the equation of activity, and of the stress function. Equation (26) is, therefore, the best form.

It should be understood that it is an identity, subject to the two laws of circuitation and the distribution of energy according to that of **E** and **H** in the field. But it should be also mentioned that in the establishment of (26) it has been assumed that the medium, as it moves, carries its intrinsic properties of permittivity and inductivity with it unchanged. That is, these properties do not alter for the same portion of the medium, irrespective of its position, although within the same unit volume these properties may be changing by the exit of one and entry of another part of the medium of different permittivity and inductivity; understanding by "medium" whatever is supporting the fluxes, whether matter and ether together, or ether alone; and it is also to be understood that the three velocities **q**, **u**, and **w** are identical, or that electrification which is always found associated with matter, moves with the medium, which is then the matter and ether, moving together. In other respects equation (26) is unrestricted as regards either homogeneity and isotropy in respect to permittivity, inductivity, and conductivity (electric, and fictitious magnetic).

Whether, when matter moves, it carries the immediately surrounding ether with it, or moves through the ether, or only partially carries it forward, and what is the nature of the motion produced in the ether by moving matter, are questions which cannot be answered at present. Optical evidence is difficult of interpretation, and conclusions therefrom are conflicting.

But in ordinary large scale electromagnetic phenomena, it can make very little difference whether the ether moves or stands stock-still in space. For the speed with which it propagates disturbances through itself is so enormous that if the ether round a magnet were stirred up, artificially, like water in a basin, with any not excessive velocity, the distortion in the magnetic field produced by the stirring would be next to nothing.

Strictly speaking, when matter is strained its elastic and other constants must be somewhat altered by the distortion of the matter. The assumption, therefore, that the permittivity and inductivity of the same part of the medium remain the same as it moves is not strictly correct. The dependence of the permittivity and inductivity on the strain can be allowed for in the reckoning of the stress function. This matter has been lately considered by Prof. Hertz. But the constants may also vary in other ways. It is unnecessary to consider here these small corrections. As usual in such cases, the magnitude of the expressions for the corrections is out of all proportion to their importance, in relation to the primary formula to which they are added.

§ 72. From the form of the expression for **A** in equation (20), viz., the flux of energy due to the stress, we may derive the expression for the electromagnetic stress itself. If the stress were of the irrotational type considered in works on Elasticity, we could do this by means of the formula (10), § 68. But for a stress of the most general type the corresponding formula is

$$\mathbf{A} = -\mathbf{Q}_q q, \quad . \quad . \quad . \quad . \quad . \quad . \quad (28)$$

where $\mathbf{Q}_q$ is the stress vector conjugate to $\mathbf{P}_q$; these are identically the same when the stress is irrotational. This gives

$$\mathbf{Q}_N = \mathbf{D}.\mathbf{E}\mathbf{N} + \mathbf{B}.\mathbf{H}\mathbf{N} - \mathbf{N}(\mathrm{U} + \mathrm{T}), \quad . \quad (29)$$

from which we obtain $\mathbf{P}_N$ by merely exchanging **E** and **D**, and **H** and **B**; thus

$$\mathbf{P}_N = \mathbf{E}.\mathbf{D}\mathbf{N} + \mathbf{H}.\mathbf{B}\mathbf{N} - \mathbf{N}(\mathrm{U} + \mathrm{T}). \quad . \quad . \quad (30)$$

This is the stress vector for any plane defined by **N**, a unit vector normal to the plane.

But it is only in eolotropic bodies that we have to distinguish between the directions of a force and of the corresponding flux. Putting these on one side, and considering only ordinary isotropy, the interpretation is simple enough. It will be observed that the electromagnetic stress (30) divides into an electric stress

$$\mathbf{E}.\mathbf{D}\mathbf{N} - \mathbf{N}.\tfrac{1}{2}\mathbf{E}\mathbf{D}, \quad . \quad . \quad . \quad . \quad . \quad (31)$$

and a magnetic stress

$$\mathbf{H}.\mathbf{B}\mathbf{N} - \mathbf{N}.\tfrac{1}{2}\mathbf{H}\mathbf{B}. \quad . \quad . \quad . \quad . \quad . \quad (32)$$

To find their meaning, take **N** in turns parallel to and perpendicular to the force **E** (or to **D**, since its direction is the same).

In the first case, the stress (31) becomes

$$\mathbf{N}(\mathbf{E}\mathbf{D} - \tfrac{1}{2}\mathbf{E}\mathbf{D}) = \mathbf{N}.\tfrac{1}{2}\mathbf{E}\mathbf{D} = \mathbf{N}\mathrm{U},$$

indicating a tension parallel to the electric force of amount U per unit area.

In the second case, when **N** is perpendicular to **E**, we have $\mathbf{D}\mathbf{N} = 0$, so that the stress is

$$-\mathbf{N}\mathrm{U},$$

that is, a pressure of amount U. This applies to any direction perpendicular to **E**, so that the electric stress consists of a tension U parallel to the electric force, combined with an equal lateral pressure.

Similarly the magnetic stress consists of a tension T parallel to the magnetic force, combined with an equal lateral pressure.

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It will also be found that the tensor of the electric stress vector is always U, and that of the magnetic stress vector is always T. The following construction (Fig. 5) is also useful:—

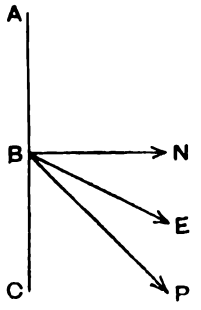

Fig. 5.

Let ABC be the plane on which the electric stress is required, BN the unit normal, BE the electric force, BP the stress. Then **N**, **E**, and **P** are in the same plane, and the angle between **N** and **E** equals that between **E** and **P**. Or, the same operation which turns **N** to **E** also turns **E** to **P**, except as regards the tensor of **P**.

To show the transition from a tension to an equal pressure, imagine the plane ABC to be turned round, and with it the normal **N**. Of course **E** remains fixed, being the electric force at the point B. Start with coincidence of **N** and **E**. Then **P** also coincides with them, and represents a normal pull on the surface A B C. As **N** and **E** separate, so do **E** and **P** equally, so that when **E** makes an angle of 45° with **N** the normal pull is turned into a tangential pull, or a shearing stress, **P** being now at right angles to **N**. Further increase in the angle **E** makes with **N** brings BP to the other side of BC; and when **E** is at right angles to **N**, we have **P** and **N** in the same line, but oppositely directed. That is, the tension has become converted into an equal pressure.

(To be continued.)

EXPERIMENTS ON THE ELECTRIC DISCHARGE IN VACUUM TUBES.

The beautiful and suggestive experiments on the electric discharge in vacuum tubes, shown by Prof. J. J. Thomson on the occasion of the visit of the Physical Society to Cambridge, in May, have excited considerable attention, and the illustrated account of them, which appeared in *The Electrician* of May 22nd, has been widely reproduced both in America and in France. In America the publication of Prof. Thomson's experiments has resulted in some interesting contributions to the *Electrical Engineer* of New York, by Prof. Elihu Thomson and Mr. Nikola Tesla, who appear to have been pursuing the same fruitful line of research. The *raison d'être* and the practical bearing of the phenomena described are not as yet apparent, but they seem to be of the order likely to yield valuable results both to the devotee of pure science and the patentee; indeed, Mr. Nikola Tesla has already brought the results of some of those striking experiments of his recently made public within the cognisance of the American Patent Office. However simple the future explanation, and however far-reaching the possible practical applications of these phenomena may be, they appeal at present mainly to the students of pure science, and to them the following notes by Prof. Elihu Thomson and Mr. Nikola Tesla will be of interest:—

"I have been much interested," says Prof. Elihu Thomson, in the *New York Electrical Engineer* of June 24th, "in the account of novel phenomena given under the title 'Some Experiments on the Electric Discharge in Vacuum Tubes,' by Prof. J. J. Thomson, inasmuch as several months ago I tried the same, or a very similar, experiment. Briefly, my experiment was performed with a closed ring made of a glass tube about one inch in diameter, the external diameter of the ring being about six inches. This was exhausted and laid alongside of a single turn of heavily insulated wire, which formed part of the discharge path from the outside of a Leyden jar, arranged to be charged and discharged rapidly by a Toepler-Holtz machine. It was found that at every discharge of the jar there was a discharge in the tube giving a band of light in the vacuous space. The accompanying engraving (Fig. 1) shows the arrangement of apparatus as just described. Curiously enough, the experiment of Prof. J. J. Thomson, in which a small pellet of mercury in an exhausted tube stopped the discharge, had its counterpart in my own experiments, as follows:—I had constructed a two-way discharge tube (Fig. 2). One branch, *a*, was large in diameter, and the branch *b* was of barometer-tube section. Wires sealed at *c*, *d* enabled a discharge to be passed. A small globule of mercury was placed in the tube, and could be shaken down into the barometer tube

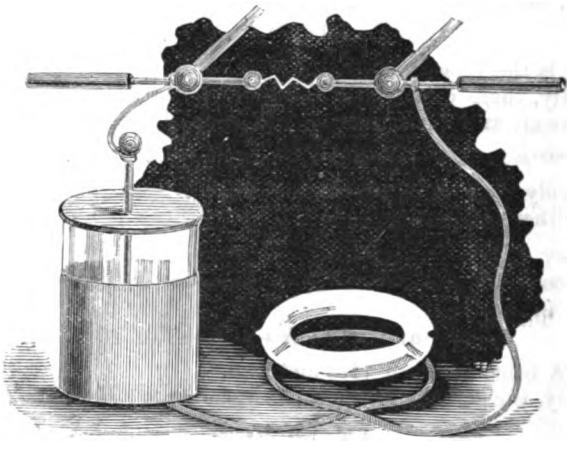

Fig. 1.

and out into the large tube at will. Though the discharge would not always divide and pass through both tubes from *c* to *d*, it sometimes did; but the interposition of the mercury globule in the small tube stopped the discharge through it.

Mr. Nikola Tesla, writing to the same journal (*Electrical Engineer of New York*, July 1), says:—"I have noted the description of some experiments of Prof. J. J. Thomson, on the 'Electric Discharge in Vacuum Tubes,' and in your issue of June 24th, Prof. Elihu Thomson describes an experiment of the same kind. The following lines are not penned with any desire on my part to put myself on record as one who has performed similar experiments, but with a desire to assist other experimenters by pointing out certain peculiarities of the phenomena observed, which, to all appearances, have not been noted by Prof. J. J. Thomson, who, however, seems to have gone about systematically in his investigations, and who has been the first to make his results known. These peculiarities noted by me would seem to be at variance with the views of Prof. J. J. Thomson, and present the phenomena in a different light.

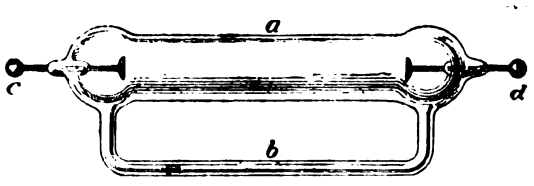

Fig. 2.

"My investigations occupied me principally during the winter and spring of the past year. During this time many different experiments were performed. Fig. 3 may serve as an example of one of the many forms of apparatus used. This consisted of a large glass tube, sealed at one end and projecting into an ordinary incandescent lamp bulb. The primary, usually consisting of a few turns of thick, well-insulated copper sheet, was inserted within the tube, the inside space of the bulb furnishing the secondary. This form of apparatus was arrived at after some experimenting, and was used principally with the view of enabling me to place a polished reflecting surface in the inside of the tube, and for this purpose the last turn of the primary was covered with a thin silver sheet.

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"I have found that it is preferable to use in these experiments an alternate current machine, giving a moderate number of alternations per second, to excite the induction coil for charging the Leyden jar which discharges through the primary shown diagrammatically in Fig. 4, as in such case, before the disruptive discharge takes place, the tube or bulb is slightly excited and the formation of the luminous circle is decidedly facilitated. But I have also used a Wimshurst machine in some experiments.

"Prof. J. J. Thomson's view of the phenomena under consideration seems to be that they are wholly due to electro-magnetic action. I was, at one time, of the same opinion, but upon carefully investigating the subject I was led to the conviction that they are more of an electrostatic nature. In support of my view I will describe a few experiments

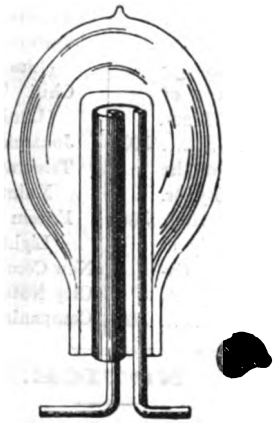

Fig. 3

made by me. To excite luminosity in the tube it is not absolutely necessary that the conductor should be closed. For instance, if an ordinary exhausted tube (preferably of large diameter) be surrounded by a spiral of thick copper wire serving as the primary, a feebly luminous spiral may be induced in the tube, roughly shown in Fig. 5. In one of these experiments a curious phenomenon was observed; namely, two intensely luminous circles, each of them close to a turn of the primary spiral, were formed inside of the tube, and I attributed this phenomenon to the existence of nodes on the primary. The circles were connected by a faint luminous spiral, parallel to the primary and in close proximity to it. To produce this effect I have found it necessary to strain the jar to the utmost. The turns of the spiral tend to close and form circles, but this, of course, would be expected, and does not necessarily indicate an electro-magnetic effect; whereas the fact that a glow can be produced along the primary in the form of an open spiral argues for an electrostatic effect.

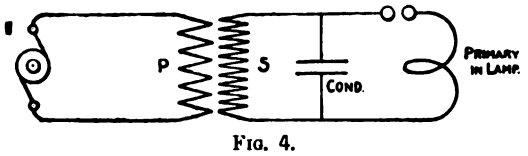

Fig. 4.

"Another experiment performed is illustrated in Fig. 6. In this case an ordinary lamp-bulb was surrounded by one or two turns of thick copper wire, P, and a luminous circle, L, excited in the bulb by discharging the jar through the primary. The lamp-bulb was provided with a tinfoil coating on the side opposite to the primary, and each time the tinfoil coating was connected to the ground, or to a large object, the luminosity of the circle was considerably increased. This was evidently due to electrostatic action.

"In other experiments I have noted that when the primary touches the glass the luminous circle is easier produced and is more sharply defined; but I have not noted that, generally speaking, the circles induced were very sharply defined, as Prof. J. J. Thomson has observed; on the contrary, in my experiments, they were broad, and often the whole of the bulb or tube was illuminated; and in one case I have observed an intensely purplish glow, to which Prof. J. J. Thomson refers. But the circles were always in close proximity to the primary, and were considerably easier produced when the latter was very close to the glass.

"Another observation made by me was that when the specific inductive capacity of the medium between the primary and secondary is increased, the inductive effect is augmented. I have likewise noted that when a bulb is surrounded by a wire closed upon itself and in the plane of the primary, the formation of the luminous circle within the bulb is not prevented. But if, instead of the wire, a broad strip of tinfoil is glued upon the bulb, the formation of the luminous band was prevented.

"Some of the experiments of Prof. J. J. Thomson also would seem to show some electrostatic action. For instance, in the experiment with the bulb enclosed in a bell jar, I should think that when the latter is exhausted so far that the gas enclosed reaches the maximum conductivity, the formation of the circle in the bulb and jar is prevented because of the space surround-

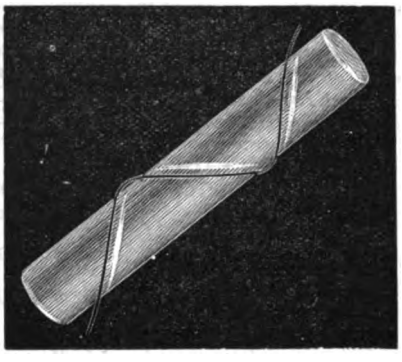

Fig 5

ing the primary being highly conducting; when the jar is further exhausted the conductivity of the space around the primary diminishes, and the circles appear necessarily first in the bell jar as the rarefied gas is nearer to the primary. But were the inductive effect very powerful they would probably appear in the bulb also. If, however, the bell jar were exhausted to the highest degree they would very likely show themselves in the bulb only—that is, supposing the vacuous space to be

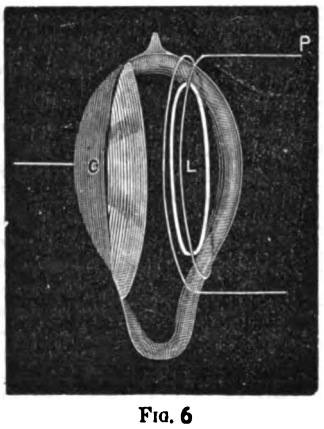

Fig. 6

non-conducting. On the assumption that in these phenomena electrostatic actions are concerned we find it easily explicable why the introduction of mercury or the heating of the bulb prevents the formation of the luminous band or shortens the after-glow; and also why, in some cases, a platinum wire may prevent the excitation of the tube. Nevertheless some of the experiments of Prof. J. J. Thomson would seem to indicate an electro-magnetic effect. I may add that in one of my experiments in which a vacuum was produced in the Toricellian method, I was unable to produce the luminous band, but this may have been due to the weak exciting current employed.

"My principal argument is the following: I have experimentally proved that if the same discharge which is barely sufficient to excite a luminous band in the bulb when passed through the primary circuit be so directed as to exalt the electrostatic inductive effect an exhausted tube, devoid of electrodes, may be excited at a distance of several feet."

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MORDEY-WILLANS COMBINATION RUNNING IN PARALLEL.

It is well known that certain alternate current dynamos will run in parallel with the greatest ease and certainty, while others cannot be made to get into step, or rather refuse to keep in step when they have been switched in together. Among the reasons which have been put forward with an endeavour to account for this obstinate behaviour, it has been suggested that almost all successful parallel running has hitherto been accomplished with belt or rope driven dynamos, and that at all events one failure of a most complete character was attributed to the fact that Willans engines were employed. It has further been alleged that the successful running of the alternators at Rome, where the machines are coupled direct to high speed horizontal engines, is to be attributed to the delicacy of the governors with which these engines are provided. Without entering on the thorny path of discussion of absolute priority, we may assert that it is generally acknowledged that, with the exception of an experiment at the North Foreland Lighthouse, several *obiter dicta* of a mathematical character, and some unpublished work at Rome, Mr. MORDEY first demonstrated in an engineering fashion the perfect feasibility of running alternators in parallel. It may be remarked, *en passant*, that the publication of Mr. MORDEY's experiments, while it set other manufacturers at work to imitate and reproduce them, after the fashion of Moses and the magicians, completely silenced the favourite cry of the low-pressure engineers who were wont to hold up the parallel running of continuous current dynamos as one of the important merits of their system.

It is hardly necessary to say that both MR. MORDEY and Messrs. WILLANS and ROBINSON declined to admit that there was

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any truth in the suggestion to which we have referred. The former was so confident that his machines when once in step would keep in step, and would not be troubled by direct and rigid connection to an engine, and Mr. Willans being well justified in believing that he not only understood his own engine better than other engineers did, but that he, perhaps, knew even more about it than they knew about their own dynamos, afforded an opportunity for a practical test of the matter as soon as the question was raised by some probable purchasers of the combined machinery. On Tuesday last experiments were made at the engine works at Thames Ditton with two A. 9 Mordey alternators, each capable of an output of 50 H.P. at 666 revolutions per minute, the one being the machine commonly used for testing at the Lambeth Works; and the other a similar machine of an early pattern, used for occasional work. Two Willans engines, of their two-crank E size, were taken from stock, and were coupled direct to the dynamos. The governors were of the ordinary kind, simply taken from the stores, and used without any special adjustment. Neither the engines nor the dynamos were arranged specially for the work, nor were they suited for each other as regards output and speed. A pair of transformers were arranged in the usual way as a synchroniser, and a pair of lamps were placed in series with the secondary coils. The engines were started, and ran at about 472 revolutions per minute. Before attempting to switch them together, the great regularity of speed of the two engines, as shown by the synchronising lamps, was very remarkable. The lamps glowed and faded at first rapidly, and as soon as both stop valves were open, and the full-speed attained, it was possible, by adjusting the governor of one to slow down the synchronisms to less than four a minute, and one long glow taken at random timed 28 seconds. It was very easy to select the best moment for switching on, and this being done both at light load, half, and full load, the fact was proved, which, though perhaps a foregone conclusion, had not actually been proved before, that a flexible driving, by belt or other elastic connection is not only not necessary, but does not appear to offer any appreciable advantage, except in cases where the speed of the engine is very irregular during each revolution, owing to irregular turning moment. A load of about 36 kilowatts was put on, and the steam was shut off from one engine, leaving only about 5lb. to keep the connecting rod from lifting. The one machine took the load and drove the other as a motor, taking with it the engine, which requires about 25lb. of steam to move it. Some further experiments were carried out afterwards, to try the effect of a considerable resistance in the circuit connecting the two machines, and during these tests the switch was more than once intentionally pulled over a little before the moment when the lamps showed that the two machines were exactly in step, but the two armatures adjusted themselves instantly without any perceptible shock or noise.

We have recently discussed at some length some of the possible reasons why certain machines can be run together, and why others refuse to keep in step. These experiments remove one uncertainty in a most satisfactory and conclusive manner, and show that the difficulty is of a purely electrical nature, and depends probably on the presence of iron in the armature and the frequency of the alternations, because, at high frequencies, there is not time for the iron to respond to the pull. The Zipernowski dynamos run easily together with a frequency of 42, and the inventor says that he can run his dynamos in parallel with this frequency "easier and in a more simple manner than with a higher one," but he has mechanical reasons for not increasing the number of alternations. In stations where alternating dynamos are used which cannot run in parallel, the only way to ensure that each is fully loaded is to keep an incessant watch on the ammeters and to distribute the various circuits. When the load is rising and another machine has to be started, a number of partially loaded circuits must be put on, and as the current in these increases some must be taken off and given to the others. Constant watching and immediate attention are needed to ensure anything like a full load on every dynamo, and it is only when each engine is either well employed, or standing, that a satisfactory coal consumption can be arrived at. But such a station is at a disadvantage, and the imperfection of the system is felt both in the increased cost of attendance and in the continual blinking of the lights, though station attendants fondly imagine that they handle the switches with such dexterity that the consumers fail to notice these brief extinctions.

OBITUARY.

WILLIAM HENRY STONE.

We are sorry to record the death of Dr. William Henry Stone, at his residence, Geraldine-road, Wandsworth, in the 62nd year of his age. Dr. Stone was the son of the late Canon Stone of Canterbury, and was educated at Oxford, where he won an open scholarship at Balliol College, and took his degree in 1852. From Oxford he went up to St. Thomas's Hospital to study for the medical profession, and took the degree of M.B. at Oxford in 1856. He became Fellow of the Royal College of Surgeons in 1856, and of the Royal College of Physicians in 1863, and was Censor of the College in 1884. He was appointed Assistant Physician, and afterwards Physician, to St. Thomas's Hospital, and was for many years Lecturer on Physics at the same hospital. He was also Assistant Physician to the Consumption Hospital at Brompton, and Consulting Physician to the Clergy Mutual Insurance Company, and Superintendent and Inspector of the Board of Health, Trinidad. A severe illness some few years back compelled him to give up many of his active duties, and he was then appointed Consulting Physician to St. Thomas's Hospital, an honorary distinction which he enjoyed till his death. Dr. Stone's intellectual qualities were of a briliant order, and he was a sparkling and witty conversationalist, but his temperament could not endure the drudgery of private practice. His chief delight was in physical work and research, principally in the domains of Acoustics and Electricity. He was an excellent musician, and one of the very few amateurs who played in the Philharmonic and other first-rate orchestral concerts, generally playing the double-bassoon, an instrument which was practically his own invention. He was also the author of a book on Sound, and of another on the Scientific Basis of Music.

Dr. Stone will, however, be chiefly remembered in the electrical world by his experiments on the effects of electricity upon the human body, a line of research for which his training as a physician and as a physicist doubly fitted him.

In December, 1884, Dr. W. H. Stone exhibited before the Physical Society an ingenious tuning fork interrupter commutator. At the Southport meeting of the British Association in 1883, he gave a short account of some experiments which showed that the resistance of the living human body to electrical currents was considerably less than that then given in all works on medical electricity, and he returned to the subject at the Aberdeen meeting in 1885. In the spring of 1886 Dr. Stone delivered a series of three lectures on "The Electrical Conditions of the Human Body" before the Royal College of Physicians. Dr. Stone was unmarried, and spent the greater part of his income on physical apparatus for his own researches, and for illustrating experimentally his lectures at the hospital, which were consequently very popular with the students.

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THE HISTORICAL DEVELOPMENT OF THE INDUCTION COIL AND TRANSFORMER.

BY DR. J. A. FLEMING, M.A.

(Continued from page 248.)

§ 13. **Ruhmkorff's Induction Coils.**—In 1851, M. Ruhmkorff, a skilful mechanician in Paris, profiting by the experiments of Masson and Breguet, and probably not aware of the researches of Callan and Page, addressed himself to the problem of increasing the spark-producing power of the induction coil, with the object of exalting the electrostatic effects which Masson and Breguet had produced. He paid the greatest attention to the insulation of the secondary coil, insulating the covered wire by passing it through melted shellac, and separating each layer of wire from the next by means of varnished silk or shellaced paper. He greatly lengthened the secondary circuit, employing in some coils five or six miles of secondary wire, and he insulated with care the primary from the secondary circuit by employing a glass tube on which to wind the secondary circuit, and glass cheeks to preserve the wire in place at the ends. He also supported the ends of the secondary wire on glass pillars. He provided, also, a simple form of current-reverser to change the direction of the primary circuit, and greatly improved the action of the vibrating hammer interrupter. The greatest service was, however, rendered by Fizeau by his application of the condenser (*Comptes Rendus*, 1853, Vol. XXXVI., p. 418), and Ruhmkorff carefully studied the appropriate dimensions of the condenser. This condenser he made at first of a sheet of oiled silk, covered on both sides with tinfoil; later he employed sheets of well-selected paper, carefully varnished, and coated with tinfoil on each side. This condenser was placed in the base of the induction coil, and the two terminals of the condenser connected to the two opposite sides of the "break" points. The condenser was made by varnishing close-grained but thin paper with shellac varnish. Each sheet was then examined for defects. A number of sheets of tinfoil were cut, each somewhat less in size than the sheets of varnished paper. A pile was made by building up alternate sheets of paper and tinfoil, placing each alternate sheet of tinfoil so as to protrude from the paper pile on opposite sides. The pile was then compressed, and all the tinfoil sheets on one side connected together, and also those on the other. Hence the arrangement formed a compact kind of Leyden jar, of which one set of tinfoil sheets formed the "outside" and the other set the inside surfaces, the varnished paper being the dielectric.* In the larger sized coils Ruhmkorff found it convenient to revert to the mercury-break of Page, and this was modified and re-invented by Foucault, who again suggested the advantages of making a break by withdrawing a steel or platinum point from a mercury surface, covered with alcohol or oil. Aided thus by Fizeau and Foucault, Ruhmkorff produced induction coils which enabled him to obtain secondary sparks several centimetres in length. It was, however, found that the tendency to internal sparking, and to rupture of the insulation of the secondary circuit, became very great when the coils were enlarged beyond a moderate size. In his later coils, after 1855, Ruhmkorff adopted a mode of construction which was suggested by Poggendorff, Stöhrer, and l'Abbé de la Borde, about 1854, viz., to wind the coil in sections so that no two portions of the wire which are closely adjacent are at very different potentials. When a coil is built up by winding layer over layer in the ordinary manner, the ends of the layers of wire, and particularly the similar ends of the first and last layers, are at very different potentials, and there is a great tendency for the discharge to pass between these points. In fact the sparking distance of the coil is limited by the distance of these portions of the wire. Under these conditions internal sparks were found to pass and to break down the insulation of the secondary circuit. The suggestion to wind the wire in separate partitions originally came from the English electricians, Edward and Charles Bright, who, in a patent taken out in 1852,* describe a method of thus winding electro-magnets, and in their fourteenth clause say, "The manner in which our fourteenth improvement may be carried into effect is as follows:—It is well known that the ordinary mode of winding the wire on coils is to wind it backwards and forwards upon the core. Our improved plan is to divide the core lengthways into compartments, by means of separating pieces fastened to the body of the coil, before winding and dividing the coil into compartments. In winding the wire, one end compartment is filled, and then the next, and so on." In adopting this method of winding, the flat coils of wire can be wound independently, and are then so joined up that the outside end of the wire on one coil is joined to the outside end of the wire of the next compartment, and yet the winding follows the same direction in each bobbin or separate flat coil. Hence no two portions of the wire at very different potentials are very close to each other, or, if they are, they are well insulated.

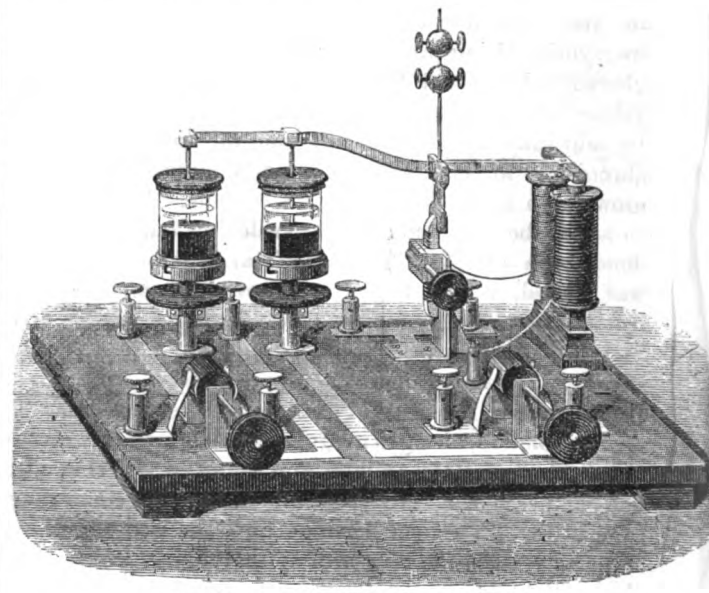

FIG. 22.—Ruhmkorff's Mercurial Break.

One of Ruhmkorff's largest coils made about 1867 was 52 centimetres in length, and the secondary circuit was divided into 80 flat coils or partitions, each compartment being occupied with five or six spirals—that is, being of a width equal to five or six times the diameter of the covered wire. The secondary circuit consisted of copper wire one-tenth of a millimetre in diameter, and 100,000 metres, or 62 miles, in length. The different compartments of the secondary circuit were insulated from one another with shellaced paper or varnished silk, and the different layers of wire in each compartment also insulated with shellac. The secondary circuit was wound upon a tube of glass as a support. The condenser employed with this coil was formed of 100 sheets of tin of a length of 50 centimetres and a breadth of 25 centimetres, insulated with paper covered with shellac, and formed a condenser having a total surface of about 12 square metres. The primary wire in this coil had a thickness of about three millimetres. This coil could give sparks 40 centimetres in length between the ends of the secondary circuit. The coil was usually worked by the current from six large Bunsen cells. For such large coils Ruhmkorff and Foucault found the

* The theory of the action of the condenser has been discussed in Vol. I. *Alternate Current Transformer*, § 7, Chap. V. When the contact breaker is provided with a condenser whose opposite surfaces are connected to the two sides of the break points, there are two distinct kinds of sparks observable at the break. There is first the spark at "break," due to the self-induction of the primary circuit, and there is the spark at "make," due to the discharge of the condenser. Rijke made the observation that the condenser is more effective in lengthening the secondary spark of the coil when the break points, or points of contact, are of gold, copper, or silver, than if they are of platinum. The discharge spark of the condenser, when a too small condenser is employed, is very bright and hot, and sometimes welds together the platinum contact points. The remedy for this accident when it occurs is to employ a condenser of larger capacity. Callan (*Phil. Mag.* [4] Vol. XIV., p. 337, 1857) suggested the employment of amalgamated copper contacts for the break, working in or smeared with oil to prevent oxidation and increase the suddenness of the break.

* British Specification, No. 14,331, of 1852.

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hammer-break with platinum contacts quite unsuitable, since the contact points are rapidly burnt away by the spark at "break," due to the self-induction of the primary circuit, and by the additional spark at "make" of the contact, due to the discharge of the condenser. Hence they revived and improved the mercury break, covering the surface of the mercury with alcohol, and breaking the primary circuit (*see* Fig. 22) by a platinum point automatically lifted out of the mercury.*

§ 13a. Improvements on Ruhmkorff's Coils.—Ruhmkorff succeeded in producing induction coils capable of giving very long sparks from the secondary circuit, but the insulation of these coils was not always found to be permanent. Du Moncel tells us that Fizeau, in endeavouring to join up several Ruhmkorff coils with the secondary circuits in series, felt severely the need for better insulation, and that M. Jean, a simple amateur mechanician in Paris, solved the problem, in 1854, by plunging the whole coil beneath the surface of a liquid insulator, viz, oil of turpentine; and by constructing coils in this manner, insulated with a fluid insulation, Jean succeeded in getting sparks of 30 centimetres in length at a time when no one, at least in France, had approached this length.† Du Moncel says that these experiments of Jean were neglected or lost sight of, and that Ruhmkorff finally succeeded in obtaining sparks of 60 centimetres in length by building up the coil in sections. Jean's coils were built up as follows: The primary wire consisted of four layers of wire and the secondary circuit of 50 layers. The primary wire had a thickness of 1½ millimetres and the secondary ·25 millimetre. The different layers of the primary and secondary were separated from each other by well-dried blotting paper. The whole coil was placed in a glass vase and filled up with oil of turpentine. The ends of the secondary wire where they emerged from the liquid were passed through glass tubes. The whole coil was baked and dried to eradicate moisture previous to immersion in the insulating liquid. M. Jean even performed this desiccation in a vacuum, and, by taking the greatest pains to avoid contact of air after and during this drying process previous to placing it in the liquid, he obtained very extraordinary insulation. There can be little question that M. Jean was here on the right track, and that this liquid insulation had many important advantages.

§ 14. Poggendorff's Researches on Induction Apparatus.—In the *Philosophical Magazine* for July, 1855, is to be found a long Paper by Poggendorff, giving an account of his researches and suggestions with regard to the induction apparatus of Ruhmkorff. He begins by criticising the construction adopted by Ruhmkorff, as illustrated by one of his coils in the physical laboratory of the University of Berlin, and points out in the first place the defect we have already referred to in the original manner of winding the coil, and the advantages to be derived from winding the secondary coil in sections. With respect to the insulation of the wire, he advises, instead of shellac dissolved in alcohol, the use of an easily fusible insulator, such as spermaceti, or a mixture of wax and oil, or paraffin wax, or, better still, the use of a *fluid* insulator, such as vegetable oil, or oil of turpentine, so that permanent defects of insulation could not occur. He also proposed insulating the silk-covered wire by first boiling it in spermaceti to get rid of moisture and air. Poggendorff experimentally examined the construction of each element of the coil, with the object of ascertaining the best arrangement and proportions of each part. With respect to the condenser, he adopted a suggestion which apparently emanated from Halske—viz., to use mica for the dielectric, and he convinced himself of the great superiority of mica over oiled silk in this portion of the apparatus. Owing to the expense of procuring large sheets of mica, he also used very thin paper, varnished with amber varnish, as a substitute. Also he used thin gutta-percha sheet for the same purpose. Poggendorff made many experiments with the object of ascertaining the exact influence of the dimensions of the condenser upon the spark-producing power of given coils. He came to the conclusion that the stronger the primary current and the longer the primary circuit, the greater must be the capacity of the condenser in order to obtain the maximum possible secondary spark. Poggendorff established the following facts, some of which had previously been arrived at by Masson and Breguet:—

(i.) When the terminals of the secondary circuit are joined by a metallic wire, or other good conductor, induced currents at "break" and "make" of the primary circuit, which are in opposite directions, circulate in the secondary. These currents are equal in quantity, but different in electromotive force.

(ii.) If a good conducting electrolyte, such as dilute sulphuric acid, is introduced into the secondary circuit, oxygen and hydrogen are liberated at both poles of the voltameter.

(iii.) If the circuit of the secondary coil is interrupted by a thin stratum of air or gas so that the secondary circuit is not complete, then only one of the secondary currents passes, viz., that produced at the break of the primary circuit. Hence we have, then, phenomena of tension at the ends of the secondary circuit. If an electroscope is touched for a moment against one of the terminals of the secondary it will become charged, but the sign of that charge will be a matter of chance, depending on the instant when it was so touched. If, however, a spark is passed across an air-gap into the electroscope from either terminal of the secondary it will always give one kind of charge, viz., that due to the state of the secondary pole when the primary current is interrupted. The action of the condenser in strengthening the secondary current produced at the "break" of the primary is only seen when the circuit of the secondary circuit is interrupted by an air-gap or circuit of high resistance. When the secondary circuit is completed by a better conducting medium, such as a partially exhausted tube, the action of the condenser is much less apparent. Poggendorff also examined the phenomena presented when the currents from the secondary coil are employed to charge a Leyden jar. He noted the effects, independently observed by Sir W. Grove, and published by him in the *Philosophical Magazine* for January, 1855, which attend the secondary discharges when a discharging path is opened across the terminals of the condenser thus applied. Poggendorff states that, in December, 1854, he communicated to the Berlin Academy the observation that if a Leyden jar has its internal and external coatings connected respectively to the two terminals of the secondary coil, and if wires are also brought from the terminals of the secondary coil to within a short distance of each other, snapping, bright intermittent sparks will be obtained, quite different in appearance from the thin, bluish continuous sparks of the ordinary secondary discharge. *Cæteris paribus*, these discharge sparks are, according to Poggendorff, stronger the more powerful the battery, and the smaller the charged surfaces.

Grove discovered, quite independently of Poggendorff,* the effect produced by a Leyden jar connected across the secondary terminals, but he examined at much greater length the whole phenomenon. Briefly, he found it to be as follows:—If a Leyden jar has its outside coating connected to the inner end of the secondary circuit of an induction coil, and its inner coating to the outer end of that circuit, and if a pair of discharging points are connected across between the two coatings of the jar, then when the coil is set in action and the discharge points adjusted to a proper distance, loud, brilliant intermittent sparks jump across. These sparks are much more brilliant and solid than the ordinary discharge of the secondary circuit, and take place at a slightly less distance. If, now, the battery power or number of cells operating the coil is increased the effect is only to increase the sparks at the primary contact

* Foucault, *Comptes Rendus*, Vol. XLIII., p. 44, 1856.

† Jean's experiments are recorded in the *Comptes Rendus*, Vol. XLVI., p. 186, 1858. It is curious to observe that Du Moncel naturally claims priority for his countryman Jean with respect to this suggestion, to immerse the whole induction coil in oil or insulating fluid to obtain higher insulation, whilst Wiedemann (see *Galvanismus*, § 911) claims for Poggendorff the origination of the idea. Modern inventors have again become alive to the value of this suggestion, and patents have been taken out for immersing alternate current transformers in oil as a means of increasing the insulation. Mr. Brooks of late years has especially drawn attention to the use of certain oils as insulators and to the practical employment of them in cables for high pressure currents.

* See *Phil. Mag.*, Vol. IX., Series 4, 1885, p. 1.

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breaker, but not much to increase the secondary discharges. When, however, a larger Leyden jar, or another Leyden jar joined in parallel with the first, is taken and connected to the secondary the effect is immediately to decrease the primary spark and to increase the secondary spark. Hence Grove found that he could apparently go on adding cells to the battery producing this primary current, or increase the primary electromotive force and Leyden jars to the secondary circuit, or increase the capacity of the secondary circuit, over wide limits, and with each such addition the brilliancy and length of the discharges from the secondary terminal were increased. In seeking for an explanation of this effect we have to bear in mind that the Leyden jar or condenser which is joined across the secondary terminals acts as a conductor of electricity *during* the time in which the induced electromotive force in the secondary circuit is increasing in amount. Also, the capacity of the condenser reacts with the self-induction of the secondary circuit to increase the maximum potential difference at the terminals of the secondary coil in a manner to be discussed more fully later on. During the period of time in which the secondary inverse induced current is flowing into the condenser it is being charged. At the instant when the secondary induced electromotive force becomes zero the condenser begins to discharge. Owing, however, to the great self-induction of the secondary circuit of the coil the charge of this condenser does not flow back through the secondary coil, but springs across the parallel air gap, making a spark. The greater brilliancy and noise of this spark, as compared with the ordinary discharge of the secondary circuit, is due to the greater quantity of electricity which passes at each discharge. Poggendorff made some very instructive experiments with two or more induction coils,* which if they had been carefully studied by subsequent inventors might have done much to prevent misconception and error. Poggendorff took two similar induction coils, which we will call A and B, and arranged them with their primary coils *in series*. A was allowed to give sparks from its secondary circuit whilst the secondary circuit of B remained open and having its soft iron core removed. The introduction of the soft iron core into the primary coil of B at once weakened the sparks from the secondary circuit of A. Hence, says Poggendorff, it follows that "two complete instruments combined one after the other mutually disturb one another, and the total effect is not equal to the sum of the effects which each would produce with the same intensity of galvanic current."

He then modified the experiment by placing the coils A and B *alongside* of one another, so that the primary circuits were joined in parallel, and he found that the insertion of the soft iron core into B *increased* the sparks given by A. He found that in the first case, when the primaries were in series, the closing of the secondary circuit of B again reproduced the sparks at their former intensity at the secondary circuit of A; whilst, in the second case, when the primary circuits of the coils were in parallel, the subsequent closing of the secondary circuit of B destroyed the augmentation of the sparks at the secondary circuit of A. The explanation of these effects is obvious in the light of what is now known as to the effect of the closed secondary circuit upon the impedance of the primary circuit. When the primary coils were in series, the introduction of the iron core into B increased the impedance of the whole circuit, and hence decreased the primary current and the secondary sparks of A, but the subsequent closing of the secondary circuit of B partly annulled the impedance of the primary circuit, and hence reaugmented the secondary sparks of A. Similar explanations apply to the case of the coils with primaries in parallel. If these experiments had been carefully considered by subsequent inventors it would have been seen that induction coils with their primaries in series are not independent of each other, and that the strength of the primary current is affected by the opening or closing of the secondary circuit of any one of them. Poggendorff examined very carefully the action of the contact breaker, both when operating in air, as well as when immersed in various liquids, and also when in a good vacuum. He found that, when the contact points of the contact breaker were immersed in pure distilled water or alcohol, the length of the secondary spark was augmented, when compared with its length, when the contact breaker operated in air. He made also the curious observation that when the contact breaker on the primary circuit operated in a good vacuum its action in lengthening the secondary spark was so much increased that it produced very nearly the same effects when acting without a condenser as did a contact breaker provided with a condenser when acting in air.

(To be continued.)

* See *Phil. Mag.*, Vol. X., 4th series, 1855, p. 137.

NOTE ON THE DECREMENT OF ELECTRIC OSCILLATIONS.*

BY M. V. BJERKNESS.

The law of damping, governing the oscillations of electricity in a Hertz vibrator, can be determined in a simple manner when the two following suppositions are made:—

1. The movement of electricity in the resonator is of a simple harmonic character, like that of the bob of a pendulum when under the action of a periodic force.

2. The decrement of the oscillations in the vibrator is considerably greater than that in the resonator.

On these assumptions, the intensity of the oscillations in the resonator can be calculated as a function of the ratio of the periods of the vibrator and resonator. Sufficient indication of the method of calculation will be found in Note 5 of the recent work of M. Poincaré, entitled "Electricité et Optique." In the formula there exists only one unknown quantity—the decrement of the oscillations aroused by the vibrator—and this constant has been determined by M. Bjerkness with the aid of a series of nine resonators, whose periods varied between 0·87 and 1·13 times the period of the vibrator.

The chief result of the research is as follows:—A vibrator producing oscillations having a wave length of 4·5 metres had a logarithmic decrement equal to 0·26, so that the ratio of the amplitudes of two successive elongations in the positive direction was equal to 0·77. After twenty oscillations the electrical movements were thus negligibly small, and the phenomena could not last longer than about a millionth of a second. The spark gap was from 1 to 2 mm. in length. If it was increased the decrement was found to increase, and analogous effects could be obtained experimentally by various arrangements of the apparatus, so that the decrement could not be regarded as a constant quantity.

The value found for the logarithmic decrement of the resonator was 0·002. This number must only be regarded as a rough approximation, as the properties of the secondary spark are not well enough known for accurate calculation. A comparison of this quantity, with the corresponding number found for the vibrator, affords, however, a satisfactory confirmation of supposition (2.) given above.

The decrement of the oscillations emitted by the vibrator is so rapid that some important conclusions necessarily follow. If the waves are reflected perpendicularly at a surface, so as to retrace their former course, the interference which takes place will be the result of superposing a weak wave on a more powerful one. There will not be nodes and loops in the ordinary sense, and at a distance of some wave lengths from the mirror the differences between the maxima and minima become insensible.

Elementary reasoning shows that a resonator, placed in the field of the interfering waves, is submitted to the action of oscillating forces whose amplitude varies periodically with the distance from the mirror. In the mathematical expression for the amplitude of the oscillations set up in the resonator two wave lengths will appear, the first corresponding with the waves emitted by the exciter, and the second with the waves, which correspond with the oscillations to which the resonator naturally gives rise. If the values just given for the logarithmic decrement are approximately correct, the first set of maxima

* *Comptes Rendus*, June 22 1891.

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and minima positions will be completely masked by the second after about a dozen oscillations have passed away. If the spark in the resonator does not take place until this effect occurs, the nodes and internodes detected by the resonator will correspond with the second system, and not with the first, and it is thus possible to account for the phenomena known by the name of multiple resonance,* without the necessity of the hypothesis by means of which MM. Sarasin and De La Rive have explained their results.

M. Bjerkness acknowledges that the explanation here given was originally given by M. Poincaré, who arrived at it on purely theoretical grounds.

THE GODFROY APPARATUS FOR INCREASING THE EFFICIENCY OF SUBTERRANEAN TELEGRAPH LINES.

The extensive development in France and Germany of subterranean telegraph lines resulted in a demand for a device to render such lines as efficient as those carried overhead. In both countries much the same solution of the difficulty has been arrived at, viz., the employment, as in the case of the long

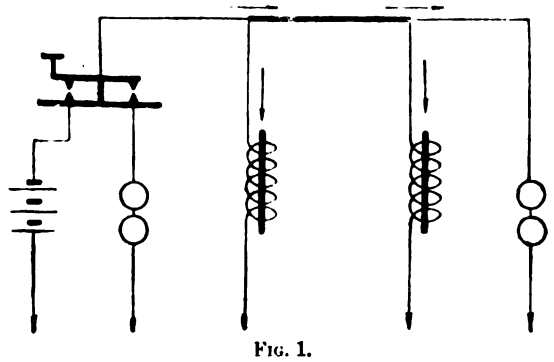

Fig. 1.

aerial lines in India, of "derivations" to earth having considerable inductance. Costly and complicated apparatus are manifestly out of place in land line telegraphy, so that modifications of the devices actually employed on, or proposed for, submarine cables were not attempted, the object being to devise something cheap and simple which could be applied without difficulty to the existing instruments. The particular arrangement favoured by the German Post Office authorities was briefly described in *The Electrician*, Vol. XXVI., p. 241; and it was stated, on the authority of Herr Grawinkel, that by means of this device it had been found possible to transmit Morse signals along subterranean wires at the same rate as on aerial lines up to distances of more than 375 miles, and that on longer lines an increase of speed of 30 per cent. was obtainable as compared with the old arrangement of fixing relays at every hundred miles or so.

In France the arrangement which has met with considerable favour is that due to M. Godfroy, which was first tested at the end of 1888. The diagram, Fig. 1 (from an article by M. H. Cailleret, in the last number of the *Annales Télégraphiques*), shows an underground circuit arranged according to M. Godfroy's simple plan. When the transmitting key is depressed the electromagnetic shunt offers a considerable impedance, and the line is quickly charged. When the key is released, and during the instant when it is neither touching the front nor the back stop, the discharge current (now aided by the E.M.F. of self-induction) goes quickly to earth through the shunt. Similar effects occur at the receiving end, and the net result is sharp, well-defined Morse signalling. In 1888 the Paris-Angoulême line, 310 miles long, having a resistance of 5,000 ohms, and a capacity of 100 microfarads, was fitted with M. Godfroy's device. An ordinary Morse instrument without either local or intermediate relays, attained a speed of 20 words a minute. The shunt circuit, which comprised an electro-magnet with a closed magnetic circuit and a small auxiliary coil, had a resistance of 780 ohms and a coefficient of self-induction of 12 henrys. The battery consisted of 50 Callaud cells. The 1888 experiments showed that, in practice, it was not absolutely necessary to ensure a perfect balancing of the inverse effects of the capacity of the line and the inductance of the shunt. Thus one electro-magnet gave equally good results on lines of from 150 to 200 miles in length, and another could be used on lines varying in length from 250 to 450 miles. It was only necessary to employ a battery suitable to the line, and either to adjust the resistance of the auxiliary coil or to break the magnetic circuit of the electromagnet more or less thoroughly by altering the positions of the soft iron armatures.

Besides the French and German experiments some were carried out on an artificial line by Dr. Tobler at the Zürich Polytechnic. A syphon recorder was placed side by side with the receiver at the transmitting end, and registered the discharge currents from the line curves I*b* and II*b*, and curves I*a* and II*a* (Fig. 2) respectively give an idea of the discharge currents at the transmitting end with and without the Godfroy electromagnetic shunt. The effect at the receiving end is shown in curves IX*a* and IX*b*. Curve IX*a* shows the signals received when the receiver was shunted by a resistance of 700 ohms. On replacing this inert resistance by one having considerable inductance, the curve IX*b* was obtained.

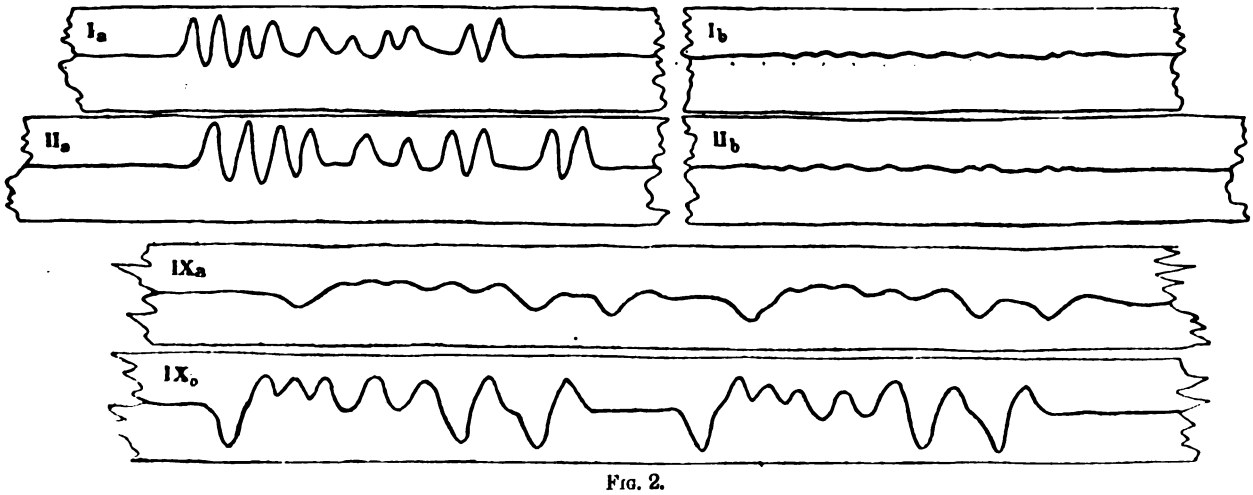

Fig. 2.

In France some 20 long subterranean circuits, such as the Paris-Lyons (300 miles), Paris-Marseilles (650 miles) lines, have had Godfroy apparatus in regular work for the past 12 months and more; and recently it was decided to apply the device to 50 additional lines of over 125 miles in length. The apparatus is made in three sizes, having resistances of respectively 500, 750, and 1,000 ohms, and coefficients of self induction of from 10 to 120 henrys. The apparatus being so simple is cheap, and does not cost more than 15 or 16 shillings.

* See *The Electrician*, Vol. XXVI., p. 701. "The Propagation of Hertzian Electrical Oscillations in Air," by MM. Sarasin and L. De La Rive, and also Vol. XXIV., p. 316.

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ELECTROLYSIS BY MEANS OF THE ALTERNATING CURRENT.

BY DR. GUGLIELMO MENGARINI.

The fundamental laws which regulate electrolysis by means of the alternating current are as follows :—

1. The quantity of electrolyte decomposed by the alternating current is always less than that decomposed by a direct current of equal strength, and depends upon the current density at each of the electrodes ; the greater the density the greater being the quantity of the electrolyte decomposed.

2. There exists a limiting current density below which electrolytic decomposition does not take place. This density varies for different electrolytes and electrodes of different materials.

3. The amount of the electrolyte decomposed decreases as the rapidity of the alternations increases.

4. A limiting value to the rapidity of alternation exists, beyond which decomposition does not take place.

In order to establish the truth of these laws, it is not necessary to formulate any special hypotheses ; it is sufficient to consider the phenomena which must be produced by an alternating current in a conductor capable of polarisation.

Suppose we have a circuit traversed by an alternating current which follows an harmonic law ; let i be the current at any time t, and I the maximum intensity ; then

$$i = \mathrm{I} \sin \pi t/\mathrm{T} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1),$$

where T is the interval contained between consecutive instants at which the current value is zero. A voltameter is inserted in the circuit, so arranged that both its resistance and that of the circuit can be varied at will, so that whilst the current is maintained constant the pressure between the poles of the voltameter can be varied as desired. To begin with, a very large resistance is inserted in the external circuit, so that the influence of the voltameter on the total circuit is small, and the difference of potential at its poles can be made to approach that occurring with an equal inductionless resistance. The value of this difference of potential at any time will be approximately represented by the expression $e = \mathrm{I\,R} \sin \pi t/\mathrm{T}$, R being the resistance of the voltameter. Suppose that, with the units adopted, R is numerically less than unity, then the maximum ordinates of the new sinoidal curve will be less than those given by (1). We thus get the two curves O A T, O B T (Fig. 1) corresponding in phase, the former representing the change in current, the latter that of the potential difference at the voltameter poles.

Whether we admit that electrolytic decomposition can take place with any electromotive force, or say that separation cannot occur when this force falls below a certain value, it is certain that we must consider polarisation at any instant as an electromotive force opposite in sign to e, and commencing either with or after the intensity phase.

But if in the following reasoning it is desired to assume that electrolytic separation cannot take place below a certain electromotive force, no alteration will have to be made. The same arguments will hold good, the only difference being, as is readily seen, that a deformed instead of a sinoidal curve must be taken to represent the polarisation. It is known that polarisation takes place in voltameters traversed by currents of very short duration (*), in the discharge of condensers (†), and with currents so small that no bubbles of gas make their appearance on the electrodes (‡). For currents lasting only a short time, the polarisation increases in proportion to the current and the time (§), so that the electromotive force due to polarisation can be represented by the expression

$$-\mathrm{P} \int i\,dt,$$

where P represents the electromotive force generated by the passage of unit quantity of electricity through a voltameter such as that considered, of which the electrodes contain unit area.(||)

If p, then, is the polarisation at any instant, we get by performing the integration

$$p = -2\mathrm{P\,I}\,\frac{\mathrm{T}}{\pi} \sin^2 \frac{\pi t}{2\mathrm{T}} \quad . \quad . \quad . \quad . \quad . \quad (2),$$

which shows that the polarisation is represented by a curve of double the period, indicated on Fig. 1 by O P 2 T. The same thing is repeated during the second period of the alternating current. Starting from any instant we can thus obtain the polarisation curve relative to that instant. It is clear, however, that after a very short time there must be a regular position for the curve, and this will accordingly be P P' P''.

In order now to obtain the curve for the difference of potential at the voltameter terminals, we have only to combine the two curves O B T B' 2 O, and P P' P'', whence we obtain the sinoidal

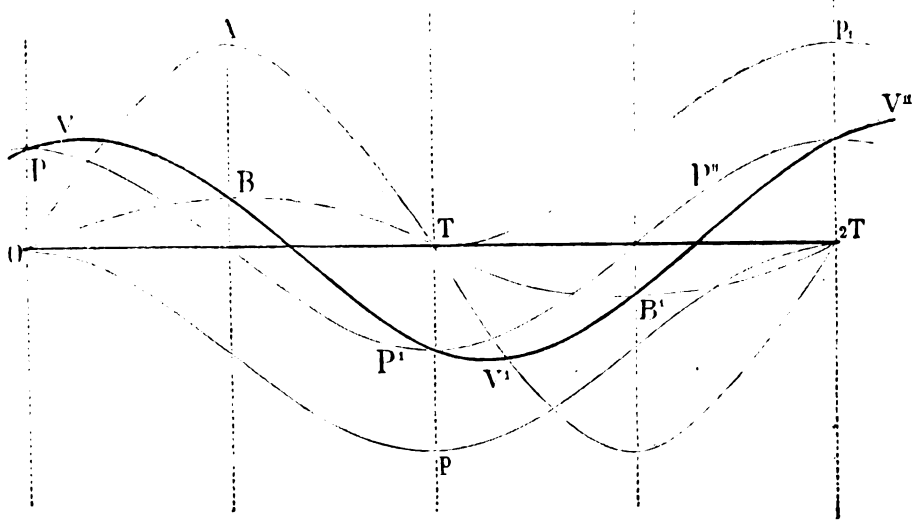

Fig. 1.

curve V V' V'', having a period equal to that of the two from which it was formed.

We see, then, that polarisation, like induction, produces a retardation of phase ; the curves for the current i and the potential difference r at the poles of a voltameter traversed by an alternating current can be represented by the equations

$$i = \mathrm{I} \sin \frac{\pi t}{\mathrm{T}}, \quad r = \frac{\mathrm{I\,R}}{\cos \alpha} \sin \left(\frac{\pi t}{\mathrm{T}} + \alpha \right),$$

where

$$\alpha = \tan^{-1} \frac{\mathrm{P\,T}}{\pi \mathrm{R}}.$$

The expression found for r shows that the phase of the difference of potential at the poles of a voltameter traversed by an alternating current is moved forward with regard to that of the current strength, just as in the effect produced by induction, so that we may say that the insertion of a voltameter in an alternating current circuit is equivalent to putting in a conductor possessing induction.

It should be observed that although we have hitherto spoken of polarisation without decomposition of the ions, still we have implicitly admitted the fact that polarisation increases in proportion to the polarising current. As this is not the case, the curves P P' P'' and V V' V'' will not be really sinoidal, at all events, as regards the longer ordinates, but, nevertheless, the reasoning given holds good. For any electrodes and electrolytes there exists a limit at which the products of decomposition commence to appear.

If we consider the case of the electrolysis of water as effected by two platinum electrodes exactly equal, and placed under the same

(*) Edlund, *Pogg. Ann.*, Vol. LXXXV., p. 209.
(†) Becquerel, *Compt. Rend.*, Vol. XXII., p. 381.
(‡) Kohlrausch, *Pogg. Ann.*, Vol. CXLVIII., p. 143.
(§) Oberbeck, *Wied. Ann.*, Vol. XXI., p. 139.
(||) Kohlrausch, *Loc.*, p. 147.

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conditions with regard to the flow of force between them and all other influences, and further grant, for the sake of simplicity, that the polarisations due to hydrogen and oxygen are equal (although it is not quite certain that they are so, the values found for them by different observers exhibiting slight differences), we can then denote by the two lines C D, E F (Fig. 2), which are parallel to and equidistant from the axis of abscissæ, the limits which must be reached by the polarisation of any given element before the giving off of gas commences.

If the current density at the electrodes is such that the polarisation reaches and exceeds this limit, the polarisation curve can no longer present the sinoidal shape shown in P P′ P″ (Fig. 1), since

Influence of the Current Density at the Electrodes.

Increasing the current density at the electrodes increases the polarisation, so that the limit of polarisation necessary to produce electrolytic separation is reached in a shorter time. This is equivalent, as is shown diagrammatically in Fig. 2, to giving a lower value to the ordinate of the straight lines C D, E F. If, for instance, this ordinate is reduced to half its value, we thus obtain the two lines C′ D′, E′ F′; O C′ and O E′, being half of O C and O E. If we suppose that to increase the current density at the electrodes their area is diminished, whilst the current strength and the rapidity of alternation remain unaltered, the maximum ordinate P I T/π of the curve representing the polarisation

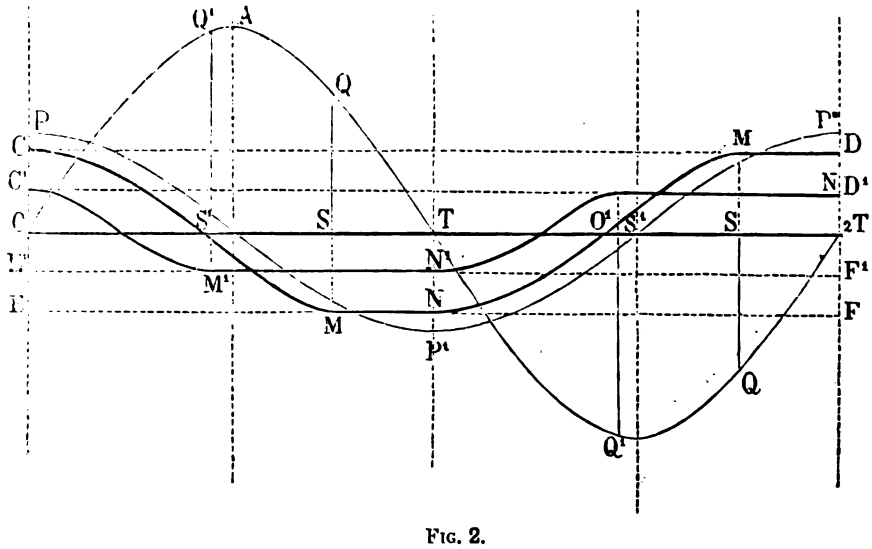

Fig. 2.

no ordinates greater than O C and O E (*see* Fig. 2) can exist. From the instant at which the polarisation attains at the point M the value O E, the liberation of gas will commence and will continue until the end of this period at N. In the interval between M and N the polarisation cannot increase, and its course is, therefore, represented by a straight line parallel to the axis of abscissæ and at a distance O E from it. From this point the polarisation diminishes according to a sine curve until it reaches the value zero at O′. Changing sign here it again reaches at M the limiting value O C, when the liberation of gas recommences, ceasing again at N, *i.e.*, at the time 2 T.

inside the voltameter, will still have its original value, so that whilst the polarisation curve P P′ P″ will still be identical with that already found, none of its ordinates will be able to exceed O C′, so that the liberation of gas will commence at M′ and cease again at N′, and the amount of the electrolyte decomposed at each alternation will be proportional to the area Q′ S′ T, which is not only larger but is more than twice as great as the area Q S T.

The same result will obtain if we suppose the area of the electrode to remain constant whilst the current traversing the voltameter is made to vary. The maximum ordinate of the curve representing the course of polarisation will increase with the

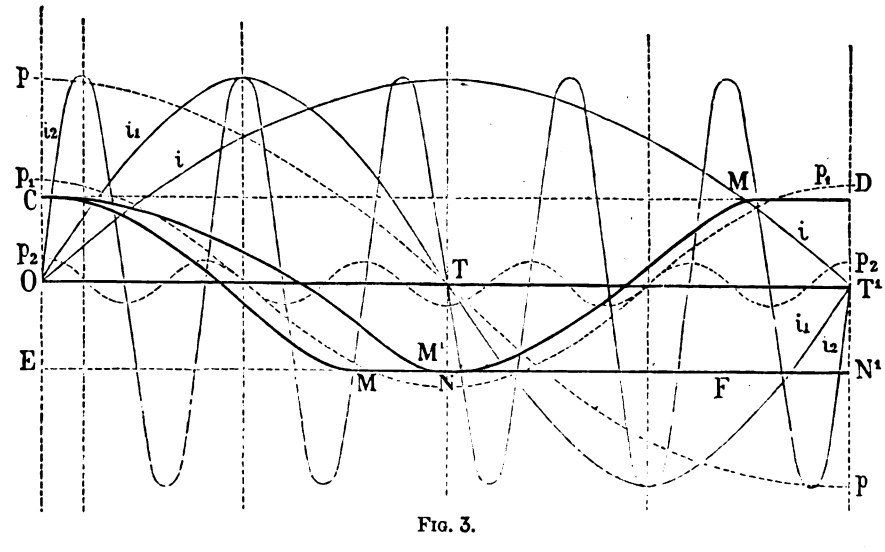

Fig. 3.

Thus during each alternation there is a fraction of the time in which electrolysis proceeds regularly, just as with a direct current, whilst during the remainder it does not take place at all. The quantity of the electrolyte decomposed at each alternation will be proportional to the area Q S T; comparing this with the total area of the curve O A T, which represents the quantity of electricity passing through the voltameter in the time T, we see that the amount of the electrolyte decomposed by an alternating current must be less, except in the limiting case when the line C D coincides with the axis of abscissæ, than that obtained with a direct current of equal quantity.

current, and the quantity of the electrolyte decomposed will increase still more rapidly in relation to the current density than it was found to do in the case considered above.

Therefore in general the quantity of an electrolyte decomposed by an alternating current when the current varies, the surface of the electrode remaining constant, is not proportional to the current passing through the voltameter.

If the current varies as a sine, and remains constant whilst its density at the electrode is made to vary, the quantity of the electrolyte decomposed at various current densities will be represented by the area enclosed by that portion of the curve contained

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between the respective moments t_0, at which electrolysis commences, and the time T, and the quantity of the electrolyte decomposed is to that decomposed by a continuous current, which causes the same quantity of electricity to pass through the voltameter, as the area enclosed by that portion of the sine curve included between the times t_0 and T is to the total area contained by the portion representing a whole alternation, that is, as

$$\text{Cos}\frac{\pi t_0}{2T} : 1.$$

If the ordinate of the lines C D, E F has the value O P (Fig. 2), electrolytic decomposition can evidently not take place, so that there exists a limiting current density below which decomposition must cease, the voltameter only becoming heated by the passage of the current like an ordinary metallic conductor.

Although there is a certain total polarisation in the voltameter, the current density at each of the two electrodes must be considered separately. The ordinate of the lines C D and E F (Fig. 2) may be different for the two electrodes, since they may be under different conditions; so that whilst one decomposes a sensible quantity of the electrolyte, the other does not. If for the special form of the electrodes, or of the voltameter, the current density is not uniform, the ions will appear only at those portions of the electrodes where the current density is greatest. This will serve to explain the anomalies found by Ayrton and Perry in examining with a Hoffman voltameter the decomposition of water by means of an alternating current.*

From the above it is clear that it is much easier to effect by means of an alternating current of sufficient density the decomposition of water, or any electrolyte giving gaseous ions, than that of one of which one of the ions is solid. And it is on account of this greater difficulty in the case of salts that many persons even now maintain that electrolytic decomposition of saline solutions with the alternating current is impossible.

Influence of the number of alternations.

If at a certain current density an alternating current effects decomposition, it is found that, on increasing the number of alternatings, the separation ceases, but commences again when the number is reduced. For every current density there is a limiting number of alternations, above which electrolysis cannot take place.

Let us denote by K the ordinate O C = O E common to the two straight lines C D, E F (Fig. 2), and by t_0, the time occupied from O to S during which electrolysis does not take place. We observe that in the sine curve C M to the abscissa t_0 corresponds the ordinate O E = − K, and for the curve O p 2 T (Fig. 1) to the same abscissa corresponds the ordinate − 2 K; thus from (2) we get

$$t_0 = T\frac{2}{\pi}\sin^{-1}\left(\sqrt{\frac{K\pi}{PIT}}\right), \quad \ldots\ldots \quad (3)$$

and, therefore, the ratio between the area contained between the times t_0 and T, and that between O and T is given by the expression $1 - K\pi/P\,I\,T$. This shows that in a given voltameter with constant current density the ratio between the quantity of electrolyte decomposed by an alternating current, and that by an equivalent continuous current diminishes as the duration of an alternation diminishes, that is, as the rapidity of alternation increases, and that there must be a limiting rapidity beyond which electrolysis cannot take place. This limit is reached when the curve C M is tangent to the line E F, its maxima ordinate being equal to K, or, in other words, when $t_0 = T$, which occurs when $T = K\pi/P\,I$.

The limiting number of alternations above which all decomposition will cease varies, therefore, in a given voltameter, with K/P and inversely with I, *i.e.*, with the polarisation of the voltameter and inversely with the current; and thus by increasing the current density at the electrodes, the effect produced by an increase in the rapidity of alternation can be counteracted.

Referring to the geometrical diagram already given to show the influence of variation in current density, we will examine the effect of variation in rapidity in the same way.

The three sine curves i, i_1 i_2 (Fig. 3) correspond to the minimum, mean and maximum number of alternations which can be obtained from ordinary alternators, say from 50 to 500 per second; the abscissa O T' representing $\frac{1}{50}$ second. The equations to the three curves may be taken as

$$i = \sin\frac{\pi t}{20{,}000}, \quad i_1 = \sin\frac{\pi t}{10{,}000}, \quad i_2 = \sin\frac{\pi t}{2{,}000},$$

time being expressed in millionths of a second and the maximum current passing through the voltameter being unity.

In order to draw the polarisation curve resulting from equation (2) it is necessary to find the value of the constant P. If we admit with Kohlrausch that a current of unit value in electro-magnetic units passing by way of platinum electrodes 1 square millimetre in area for ·000000124 seconds will produce a polarisation 1 Siemens × 1 Weber,† it follows that a current of 1 ampere decomposing water by means of platinum electrodes of one square centimetre area will give rise to a polarisation of ·0763 volt in 10^{-6} seconds. Thus expressing time in millionths of a second, the maximum ordinates of the three curves representing the polarisation and corresponding to equation (4) will be approximately 1,000, 500, and 100, giving us the three curves p p_1 and p_2 (Fig. 3), in which the ordinates of the polarisation curves are shown to a scale 500 times less than that used for the current curves. As may be seen from the figure the ordinates of the polarisation curve increase very rapidly with the length of an alternation or inversely with the rapidity. If C D, E F represent the limits which may be reached by polarisation in the voltameter without decomposition taking place, we see that p_1 and p reach this limit, whilst p_2 does not, so that when T = 10,000 millionths of a second separation appears from M to N; when T = 20,000 it occurs from M' to N'.

From this figure, then, it clearly appears that with an increase in rapidity of alternation the quantity of the electrolyte decomposed decreases, and that for every current density there exists a limiting value for the rapidity of alternations, beyond which decomposition does not take place.

(To be continued.)

* *La Lumière Électrique*, Vol. XXIX., p. 101.
† Pogg. *Ann.*, Vol. CXLVIII., p. 147.

CONTRIBUTIONS TO THE STUDY OF THE SPECIFIC INDUCTIVE CAPACITY OF LIQUIDS.*

BY A. PEROT.

Silow proposed the following method for measuring the specific inductive capacity of liquids. A quadrant electrometer, used idiostatically, is successively immersed in the two fluids to be compared. If C_1 and C_2 are the couples acting on the needle, in the two cases, for the same deflecting potential applied to the quadrants, the ratio of the specific inductive capacities of the two substances is

$$\frac{K_1}{K_2} = \frac{C_1}{C_2};$$

or, if the second medium is a vacuum, or air, for which the value of K may be assumed to be equal to unity, the value of K for the first body is simply C_1/C_2.

Thus the value of K is obtained by two successive experiments in which the positions of equilibrium of the needle are observed. It necessarily follows that if K varies with the duration of charge, it is not possible to observe any changes in its value till the oscillations of the needle have died away, and any initial changes in K are quite masked by these vibrations.

In order to study more precisely the variations in the inductive power of liquids when first subjected to electrification, M. Perot has modified Silow's method in the following manner:—An apparatus was constructed consisting of two electrometers, of which one had air as its dielectric, and had a capacity which can be varied at will, while the second is immersed in the liquid to be studied. The moving parts of the two electrometers are rigidly connected, and are arranged so that the electrical forces in the two instruments are opposed to each other. By adjusting the capacity of the air condenser forming the first instrument, it is possible to adjust the opposing forces to exact equality, so that the movable part of the apparatus experiences no resultant force when it is charged. If the instrument is so adjusted at the end of, say, five minutes after charging, one can, theoretically, at all events, deduce the values of the geometric capacities of the two condensers and the specific inductive capacity K of the body at the end of that time. Now discharge the apparatus, and charge afresh. If no motion of the movable part is observed, the value of K is independent of the time of charging, but otherwise K must be regarded as a variable.

The results obtained show that much depends upon the purity of the liquid, and M. Perot accordingly confined his attention at first to liquids rigorously deprived of water by the prolonged action of sodium. The liquids chiefly used have been benzine, the essence of petroleum, and chloroform.

The first apparatus of M. Perot consisted of a differential weight electrometer. The two attracted plates were placed at the extremities of a lever like the pans of a balance, the electrical attraction on the plates forming the weights to be compared. Under each plate an earth plate was placed. The height of one of these was adjustable, so that the attractions could be balanced; and on the other was placed a trough containing the liquid under test. After adjusting for balance when the movable plates were charged, the instrument was discharged for an instant and charged again. One of the pans was then found to move upwards, to oscillate, and finally to return to its former position of equilibrium. The motions obtained indicated that for pure anhydrous liquids K_0 was less than K, where K_0 is the specific inductive capacity at the instant of

* Abstracted from an article appearing in the *Journal de Physique*, for April, 1891.

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charging, and K the corresponding value at the end of five minutes. For impure liquids K_0 was, however, often greater than K. M. Perot considers that the results obtained must really be attributed to alterations in K, and not to differences in conducting power, because the difference between K and K_0 is sometimes positive and sometimes negative. The electrometer-balance was not much used, as actual measurements of the values of K and K_0 could not easily be made. The instrument was abandoned in favour of a differential quadrant electrometer, illustrated in Fig. 1.

This instrument consists of two Branly electrometers superposed, the two needles having a common axis, and being suspended by a

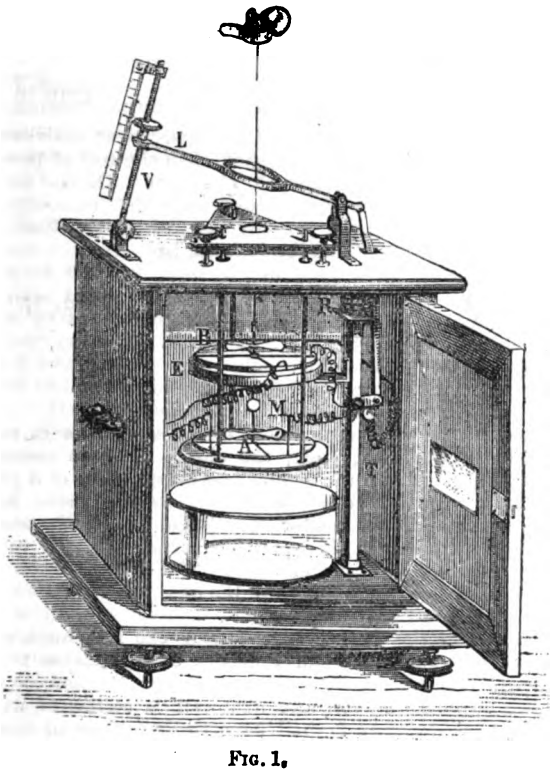

FIG. 1.

platinum wire ·05 of a millimetre in diameter. The sectors of the lower electrometer, A, are attached to a fixed support, but those of the upper electrometer, B, are movable vertically by a mechanism shown in the figure, and their position can be adjusted to about ·01 millimetre. The weight of the double needle, including the mirror M, is about four grammes. The sectors are gilt, and the interior of the case is covered with tinfoil in connection with the

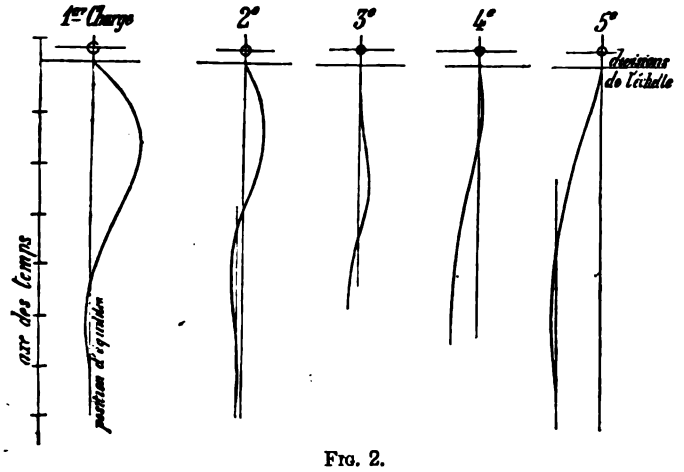

FIG. 2.

earth. The deflection of the needle is observed by Poggendorff's method. The electromotive force used was about 270 volts. The quadrant sectors are so connected that the two couples acting on the needle are opposed to each other. The following is the process used in obtaining the specific inductive capacity :—The needle is connected with a pair of sectors of each electrometer, and the upper instrument B is adjusted till the deflection is zero, when the potential is applied. Let p_1 be the reading of B for this position. Now raise the glass vessel containing the liquid till the lower electrometer is immersed, and take the new reading p_2 of B. It has been shown that the electrometer deflection remains at zero if the liquid is perfectly pure, whatever the time of charge, and that p_2 is independent of the value and the sign of the potential acting on the quadrants. In order to determine K it is now necessary to find the relative values of the two couples acting on the lower needle when the readings of B were p_1 and p_2 respectively. To do this the sectors of A are all connected to earth, while a cell of suitable voltage is applied to B when the readings are p_1 and p_2, and the respective angular deviations d_1 and d_2 are observed. Then, taking the inductive power of air as I, we have

$$K = \frac{d_2}{d_1}.$$

The following values were obtained for benzine and essence of petroleum. The square of the refractive index for the ray D of the spectrum is also added for comparison.

	K		n^2
Benzine	2·235	.....	2·25
Essence of petroleum ...	2·170	.....	2·11

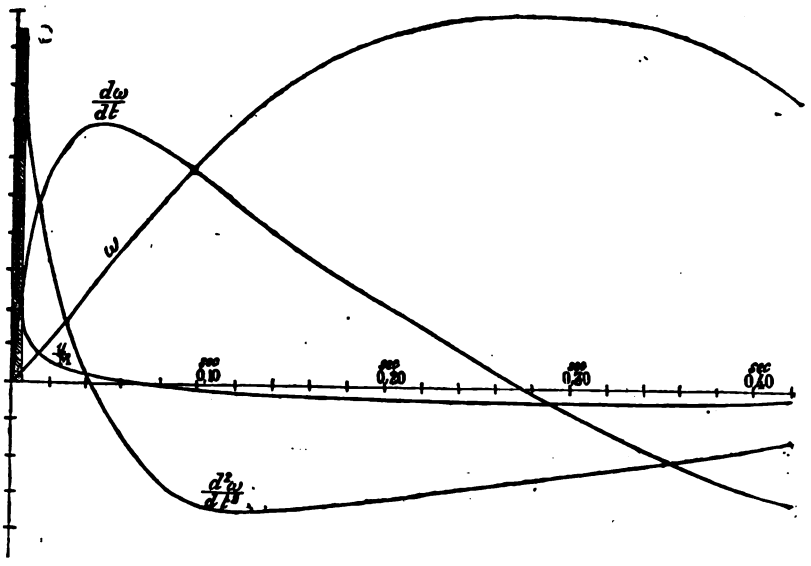

FIG 3.

In order to find the value of K_0 the instrument was adjusted five minutes after charging, was then discharged, and immediately charged again. The mirror is then observed to receive an impulse in one direction, say to the right, and returns to zero after a few oscillations. If the sectors of the air electrometer are slightly lowered the initial impulse to the right is diminished, and the final position of equilibrium is a little to the left of zero. If the sectors are still further lowered, the impulse to the right is continuously

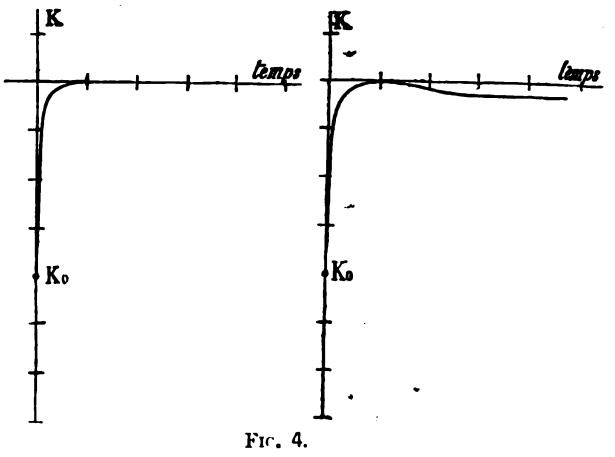

FIG. 4.

diminished. The time curves of the deflection for five successive adjustments of the electrometer B are shown in Fig. 2, and were obtained by direct photography of the movement of the needle. If we estimate the specific inductive capacity from the reading of the electrometer B (such as the 5th in Fig. 2), which corresponds to no initial impulse of the needle, we obtain a value K'_0, which is a superior limit of the value of K_0. The effect of an impulse imparted to a movable system is more and more apparent as the moment of inertia of the system is diminished, and an impulse which would not be perceptible with one needle would be rendered apparent by sub-

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stituting a lighter needle for it. The values found for K'_0 in the experiments on benzine varied from 1·65 to 1·68 for one needle, but for a very light needle it was only 1·10. This value 1·10 is the smallest value actually found, but M. Perot considers that the true value of K_0 is really unity.

The next question which M. Perot discusses is the manner in which K_0 changes until it reaches the final value K. The differential equation of the motion of the needle is of the form

$$M\frac{d^2\omega}{dt^2}+m\omega+f\left(\frac{d\omega}{dt}\right)=\mu$$

where M is the moment of inertia of the needle, m the torsional couple of the suspending wire per unit angle, $f\left(\frac{d\omega}{dt}\right)$ the couple due to the damping forces, and μ the moment due to the electrical forces. ω is the angular deflection of the needle at the instant t. The value of μ can be found from this equation if the coefficients are known, since the values of ω, $\frac{d\omega}{dt}$ and $\frac{d^2\omega}{dt^2}$ can be determined graphically from the photographed curves shown in Fig. 2. M. Perot found, by studying the vibrations of the needle when left to oscillate freely, so that no electrical forces were acting, and $\mu=0$, that the motion of the needle could be represented by the equation

$$\frac{d^2\omega}{dt^2}+0{\cdot}01834\,\omega+0{\cdot}2314\frac{d\omega}{dt}=0,$$

and hence the electrical couple at any moment may be obtained from the equation

$$\frac{\mu}{M}=\frac{d^2\omega}{dt^2}+0{\cdot}1834\,\omega+0{\cdot}2314\,\frac{d\omega}{dt}.$$

By the careful application of graphical processes to the photographic curves indicated in Fig. 2, M. Perot was able to deduce the curves connecting ω, $\frac{d\omega}{dt}$ and $\frac{d^2\omega}{dt^2}$ with the time, and thence, by application of the above equation, to find a similar curve for μ/M. The resulting curves are shown in Fig. 3. The value of K at any moment can be readily deduced from the corresponding value of μ/M. The moments of the couples acting on the needles are $C_1 V^2$ and $C_2 K V^2$, where C_1 and C_2 are constants, K is the specific inductive capacity of the liquid, and V is the potential applied to the quadrants. The difference between these moments is μ, the resultant electrical couple. Thus

$$(C_1-C^2K)V^2=\mu,$$

or,

$$K=\frac{C_1}{C_2}-\frac{\mu}{C_2V^2}=\frac{C_1}{C_2}-\frac{M}{C_2V^2}\frac{\mu}{M},$$

so that the variations of K follow those of μ. The curve representing K as a function of the time for the liquid (essence of petroleum) on which the observations were made, is like the second curve of Fig. 4, which is very similar to the first curve of the same figure.

The conclusions at which M. Perot arrives may be summarised as follows :—

1. The specific inductive capacity, after the charging potential has been applied for one second or more, depends neither on the time of charging, nor on the potential applied, nor on the previous history of the liquid. The value of K is equal to the square of the index of refraction, as required by Maxwell's theory.

2. The initial value of the specific inductive capacity is very nearly unity.

3. The rate at which the specific inductive capacity changes from its initial value, K_0, to its final value, K, is extremely rapid.

THE ELECTRIC TRANSMISSION OF POWER.*

BY GISBERT KAPP.

(Continued from page 279.)

Now let us see how such a system of transmission will have to be worked, and what the working expenses will be. I take, by way of example, five miles as the distance between the generating station, which may be the tramway depôt or a central electric light station on the line of tramway, and the delivery station. At either terminus we must have mechanical appliances for loading and unloading the batteries from the car, such as are generally used in connection with storage cars. Early in the morning a charged battery is put on the car, and run out to the delivery station, where it is unloaded and connected to the motor. The other battery, which has served during the previous day, is loaded on the car and taken back to the depôt to be charged up again. In this manner the car need only make one journey out and one journey home daily. As its speed may be very moderate, say from three to four miles an hour, the cost of running this car will be much less than that of a passenger car, which must stop and start every few minutes, and run at a higher rpeed. I take 3d. per car mile as the cost of haulage, including the use of plant, and I further allow 2s. a day for labour in loading and unloading the batteries. The account of working expenses will now stand somewhat as follows :—

	£	s.	d.
Power at generating station at £10, allowing 65 per cent. total efficiency*	77	0	0
Haulage	37	10	0
Labour	30	0	0
15 per cent. interest and depreciation on batteries (£340)	51	0	0
10 per cent. interest and depreciation on electric machinery (£150)	15	0	0
Total annual cost	£210	10	0

This works out at £42. 2s. per annum per horse-power delivered, and is therefore quite as high, if not higher, than the cost of power obtained by a small and uneconomical local engine. On the score of economy there is consequently no advantage in transmitting power by storage batteries in the present case, where the distance of transmission is five miles. Had the distance been less, the working expenses would also have come out smaller, but not by any considerable amount. The only item in which we could save is cost of haulage, and if we neglect this altogether we have still to pay £34. 12s. per annual H.P. delivered. Battery transmission can therefore not compete against power produced by a local engine, even if the latter be of the rather uneconomical type which users of small power still tolerate. But how stands the case if for some local reason the employment of a heat-engine of any kind is precluded? We have, then, the choice between electric transmission by means of batteries, and directly by means of a pair of wires. Which will be the more economical? As the dynamo and motor, except, perhaps, in the matter of voltage, will be the same in either case, the answer to this question turns upon the comparison of the batteries and line of wires. The first question to consider is whether our wires may, in the case of direct transmission, be carried overhead on poles and insulators, or must be put underground. If the former be the case, the line need not cost more than £130 per mile ; and I may at once mention that, from the experience gained with various power transmissions, which I hope to bring before you, this item can be estimated with a fair degree of accuracy. As I shall have to deal more in detail with the cost and construction of live power transmission plants later on, I shall not enter into details at present, and must ask you to take my statements as to cost of line and cost of power transmitted as correct, though I do not now show how the account is made up. As regards transmission by wires placed underground, there is, as far as I know, no example of such an installation, and we can, therefore, not verify our estimate by reference to work actually executed, as we can in the case of overhead transmission. We are thus forced to calculate the cost of the line according to the data obtainable for electric light mains, and I take for this purpose an estimate made by Mr. Crompton in his Paper on "Central Station Lighting," read before the Institution of Electrical Engineers, on the 12th of April, 1888. In this Paper Mr. Crompton gave tables for the cost of underground mains of various types and sizes, and by reference to his tables I find that a main of the section required for the transmission of 5 H.P., and insulated so as to safely bear a pressure of 1,000 volts, would cost about £670 per mile. We have now all the necessary particulars for making a comparison of the cost of battery transmission and direct transmission, the latter by both overhead and underground wires. The following table gives the result. The cost includes the charge for power at the generating station (taken at £10 per annual H.P.), and interest and depreciation on the plant, which is taken at 15 per cent. for the batteries, and 10 per cent. for the line and electrical machinery.

Transmission plant for 5 H.P.

Distance of transmission in miles.	Annual cost per H.P. delivered, if the transmission is		
	By batteries.	Direct.	
		Overhead.	Underground.
1	£36·1	£22·8	£33·6
2	39·1	25·6	47·2
3	37·9	28	60
4	40·6	30·6	74
5	42·1	33	87

* Cantor Lecture delivered before the Society of Arts, February, 1891.

* In this case, the efficiency is the ratio of the power supplied to the charging dynamo to that obtained from the motor, and does not include power spent in transmission being charged for in the account at 3d. per car-mile.

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We see from this Table that if there is no objection to an overhead line, the electric transmission of stored power by means of batteries cannot compete against the direct transmission of live power by means of a pair of wires, even if the distance is considerable. But in towns we cannot have, or at least we ought not to tolerate, overhead lines, and if we work with an underground line we find that, for distances exceeding one mile, the battery is a more economical transmitting agent than the wire. Here we have at last found a case where it will be advantageous to transmit power by means of storage batteries, but there are so many conditions attached to the case that the field of application of such a system must necessarily remain very limited. First, the power must be required, so to say, in small parcels; secondly, there must be a tram line handy, and the customer must have facilities for loading and unloading the batteries and accommodating them on his premises; thirdly, there must be a charging station on the line having similar facilities; fourthly, the use of an overhead line must be excluded; fifthly, the distance must exceed one mile; and, finally, there must be some reason why a local engine cannot be used. I need hardly point out that a system of transmission fenced in by so many conditions cannot have any commercial importance. Thus far, the result of our investigation is entirely negative. We find that transmission of power by means of storage batteries, whether the power transmitted be large or small, is not so economical as other methods of transmission, and has, therefore, no commercial value for all cases where these other methods are applicable. If I have, nevertheless, devoted some part of this lecture to the subject of battery transmission, it was because the idea of distributing power, so to speak, bottled up in batteries, seems to have a fatal charm for many inventors. It is an old idea, but is always coming up again, and for this reason I thought it advisable to go a little into figures and show you how the case really stands. It might perhaps be objected that as no distribution of stored power by means of ambulant batteries has as yet been practically introduced, it is premature to give an opinion as to the possibilities of such a system. The idea of battery distribution of power is, as a matter of fact, entertained not only by amateur electricians, but also by practical engineers. As an example of this fact, I may quote a passage in a report written about two years ago by Mr. J. F. Fanning. This gentleman, reporting to the Cataract Construction Company on the question of utilising the power of Niagara Falls, says:—"Power and lighting currents may be electrically transmitted to neighbouring cities, and possibly storage batteries may be electrically charged and re-charged, and many times forwarded for use in surrounding cities." When writing this, Mr. Fanning had, of course, in view cheap water-power, and probably canal transportation. If, at the same time, batteries could be made cheaper, lighter, and more durable than they actually are at present, then, but not until then, will they become commercially possible as transmitting agents in competition with other systems of power transmission. Taking batteries as we find them at present, their use as agents in the transmission of power is only justifiable in cases where the direct transmission by means of conductors cannot be employed; and this brings me to the consideration of the only case of the electric transmission of stored power which as yet has attained to practical importance—namely, the use of batteries for locomotive purposes.

Although electric tram-cars come strictly, speaking, within the title of my lectures, I do not propose to consider them at any length, the reason being that this branch of power transmission alone, if treated in detail, would absorb all the time at my disposal. I shall, therefore, content myself in taking up the subject only so so far as is necessary to show in a general way what is the present practice in this branch of power transmission.

We have in this country two very good examples of battery tram-cars, the one being the cars now running in Birmingham, and the other the cars on the Barking-road line in the North of London. Of the former I have not been able to obtain much information, but of the latter I have by the kindness of Mr. Thomas Fraser, who superintended the erection and working of the plant, been able to obtain all the information required for my purpose. I am also indebted to Mr. Reckenzaun for information regarding his cars, which are in use at Philadelphia. The following table gives the principal data of these cars, conveniently arranged for comparison and reference.

Taking the averages of the last two lines in the table, we find that for a car representing a total rolling weight of 10 tons, we require a battery capable of giving a maximum output at its terminals of 19 E.H.P., and a mean output of 5·6 E.H.P. It must, however, be noted that the latter figure applies to the time the car is actually in motion, and does not include the power wasted in starting. Mr. Fraser has made very careful observations of the power flowing out of the batteries during the whole of the time the car is in service, and found that the integrated power divided by time came to 7·33 E.H.P.; that is to say, a motor taking from the batteries all day long 7·33 E.H.P. will take from the batteries the same amount of power that is actually taken under the intermittent work going on in the running of a tram-car. Of the 7·33 E.H.P., a good motor will yield about 6½ B.H.P. Taking the efficiency of the batteries at 60 per cent., a figure by no means too low when we consider the very irregular nature of the work done by these batteries when in service, we find that the E.H.P. of the charging dynamos required per car is about 12 E.H.P. The ratio between the indicated power of the engine and the output of the charging dynamo may be taken at 80 per cent., so that we shall have to provide engine-power at the rate of 15 I.H.P. for every car, provided the engines are worked for the same number of hours that the cars are in service. If the engines are worked for a longer time, say by night as well as by day, a corresponding reduction in the total indicated power of the station can, of course, be made.

Storage-Battery Tram-Cars.

—	Birmingham.	Barking-road.	Philadelphia.	
			Small car.	Large car.
Weight of car (in tons)	—	3·275	2·500	3·620
„ motors gear (in tons)	—	1·360	·980	1·140
„ batteries (in tons)	2·850	2·400	1·770	2·450
„ passengers (in tons)	3·300	3·600	2·230	3·600
Total rolling weight (in tons)	10·50	10·63	7·48	10·81
Percentage of paying load	31·5	34	30	33·2
Number of cells	96	96	84	116
Maximum current	—	70	70	80
Maximum energy at battery terminals (E.H.P.)	—	19	14	23
Average energy at battery terminals (E.H.P.)	—	6	4·8	5·4
Maximum energy per 10 tons of rolling wght. (E.H.P.)	—	17·8	18·7	21·3
Average energy per 10 tons of rolling wght. (E.H.P.)	—	5·65	6·42	4·95

Returning now to the subject of the cost at which stored power can be retailed by electric transmission to small consumers, let us briefly glance at the rival system, namely, the distribution of small parcels of live power from a central electric light station. One hears it often stated that the supply of power, and not that of light, must become the chief business of such stations. The argument in support of this view is somewhat as follows:—The demand for light is very uneven, being less than a tenth of the capacity of the station for many hours during the day, and rising very rapidly towards evening. The period of large demand comprises only a few hours, and during that time the engines work with great economy. During the remainder of the day the economy is less; and, in fact, the greater portion of the coal bill, cost of attendance, and interest on the capital outlay is chargeable to light running. If, therefore, by the sale of power, we could keep the central station plant economically working during the whole of the day, the increase on the working expenses would be slight, but the increase of revenue would be very considerable. This argument is perfectly sound, but it has the rather serious defect that it will not convince the very people from whom this large increase of revenue is to be obtained; for, let us see what it means to the use of power. As you know, electric current is supplied from central stations, at a charge varying from 4½d. to 8d., and even 1s. per Board of Trade unit. The usual charge in London is about 7d. Now, suppose a small manufacturer, requiring only a few horse-power, determines to discard his small steam or gas engine, and put up an electromotor, to be worked by current from a central station, what will the power cost him? This, of course, depends on the time—that is, the number of hours in the year during which he requires power. If he has a small factory, in which work is steadily going on day by day, you may estimate that the power will be required during 3,000 hours per annum. It is now very easy to calculate the annual cost of each brake horse-power. Allowing £1. 10s. per horse-power for depreciation and interest on the motor, and £1 for petty stores, we fine that, at 7d. per unit, the annual horse-power comes to £75. With current at a different price, the cost of power will be accordingly altered, as shown in the table:—

Power Derived from a Central Station.

Cost of Board of Trade unit	d. 1	d. 2	d. 3	d. 4	d. 5	d. 6	d. 7	d. 8
Cost of annual brake horse-power for 3,000 hours	£ 12·9	£ 23·3	£ 33·5	£ 43·9	£ 54·2	£ 64·5	£ 75	£ 85·4

It is clear, from this table, that the small user of power will only use an electromotor if he can get current at about 3d. per unit, and, unless electric light companies can supply at this price (which at the present time does not seem likely) there is no prospect of supplying electric power to small factories wanting the power continuously. Another disadvantage is that the demand for power

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must, in winter at any rate, overlap the demand for light, hus requiring the erection of additional plant. If, however, the power is only required intermittently, then the electromotor is by far the cheapest instrument for producing it, not only as regards first cost, but also as regards working expenses. There are many small trades in which power is wanted only for a few hours during the day. If, for instance, the actual running time of a lathe is two hours daily, then the cost of the annual horse-power, with current at 7d. would only be £15, a figure which cannot be touched by either steam or gas. There is the further advantage of having the power always ready. There is no need to get up steam, look to the feed pump, open cylinder cocks, turn the engine over the centre, and generally do the dozen little things which are required in starting an engine. With a motor all that is required is to turn on the switch when the power is wanted, and to turn it off again when the job is done. For domestic purposes again, nothing could be more handy and economical than electric power supplied from a central station. I have here a collection of appliances, for the loan of which I have to thank the Keys Electric Company, and I can show you how easy and convenient it is to apply electric power to small domestic machinery.

I have in the present lecture dealt with what may be termed general questions of engineering policy rather than with technical details, and I am afraid you will have found the financial parts of the lecture rather a dry subject. The question of cost is, however, of the utmost importance in engineering work, and it was, therefore, necessary to give it some consideration. In the remaining two lectures I shall be able to turn to the more interesting parts of our subject, and bring before you some of the scientific principles and technical details relating to the electric transmission of live power over long and short distances.

(To be continued.)

ELECTRIC LIGHTING ORDERS.

In a Parliamentary Return, just issued, the Board of Trade state that 70 applications for Provisional Orders have been made since the issue of the last report; of these 37 were made by local authorities, and 33 by companies, and 12 related to London. The orders granted to companies have, without exception, been granted with the consent of the local authority of the district. In the case of the Order granted to the New Cadogan and Belgrave Electric Supply Company, in respect of a portion of the parish of St. Luke, Chelsea, the local authority consented to the grant of an Order to the Company, but objected to certain provisions which were inserted by the Board of Trade, at the instance of the London County Council, in accordance with their usual practice in the case of Orders relating to the metropolis. A special report with respect to this Order was made to Parliament, who recently decided to delete the clauses objected to by the Chelsea Vestry. The Orders granted this year to a great extent follow the form of the Orders granted last session; but a clause has been inserted forbidding the placing of electric lines above ground without the express consent of the Board of Trade. At the request of the Corporation of Edinburgh, the Board of Trade inserted a provision in the Bill to confirm the Edinburgh Electric Lighting Order, authorising the Corporation, with the consent of the Secretary for Scotland, to borrow money for electric lighting purposes and to keep the accounts of the undertaking authorised by the Order under the provisions of the Edinburgh Municipal and Police Acts, which regulate the other borrowing powers and accounts of the Corporation, instead of under the Electric Lighting Acts.

The following is a complete list of the Provisional Orders granted this year :—

C. = Company. L.A. = Local Authority.

Acton, L.A.	Kingston-upon-Thames, L.A.	Preston, C.
Birmingham, C.	Leeds, C.	Scarborough, L.A.
Bishop's Stortford, C.	Liverpool, C.	Southend, L.A.
Bolton, L.A.	Llanelly, L.A.	Southport, L.A.
Bromley, L.A.	London—	South Shields, L.A.
Canterbury, L.A.	Camberwell, C.	Stockport, L.A.
Cardiff, L.A.	Chelsea, C.	Sunderland, L.A.
Chiswick, L.A.	City of London, C.	Surbiton, L.A.
Coventry, L.A.	Islington, C.	Torquay, L.A.
Croydon, L.A.	North London, C.	Toxteth Park (Liverpool), C.
Dewsbury, L.A.	Southwark, C.	Tunbridge Wells, L.A.
Ealing, L.A.	Wandsworth, C.	Tynemouth, L.A.
Edinburgh, L.A.	Westminster, C.	Weston-super-Mare, L.A.
Exeter, C.	Woolwich, C.	Weybridge, C.
Hanley, L.A.	Londonderry, L.A.	Whitby, L.A.
Harrogate, L.A.	Newcastle, C.	Whitehaven, L.A.
Heckmondwike, L.A.	Newport (Mon.), L.A.	Withington (Manchester), C.
Hertford, L.A.	Norwich, C.	
Ipswich, C. (2)	Paisley, L.A.	
Kidderminster, L.A.	Poole, C.	
Killarney, C.		

In all, 58 of the 70 Orders applied for have been granted, 34 to local authorities, and 24 to companies.

Bills Nos. 1 to 4, confirming these Orders, received Royal Assent on June 11th. Bills Nos. 5, 6, 7, 9, and 11 are awaiting Royal Assent. The other Bills are still before Parliament.

No applications for licences have been received since the date of the last report. But the two licences referred to in the last report were granted. These were to Crompton and Co. (the Borough of Chelmsford), and Mr. H. G. Massingham (Bath).

Since 1883 no less than 218 Provisional Orders have been granted. Of these, 61 have been revoked or repealed, leaving 157 still in force, 94 of which belong to local authorities. During the same period 20 licences have been granted, only 12 of which now remain in force. During the electric lighting mania of 1882-83 69 Orders were granted, only 13 of which (all belonging to local authorities) still exist.

PARLIAMENTARY INTELLIGENCE.

HOUSE OF COMMONS.—JULY 14TH.

The Patent Office.

Mr. LENG rose to move the reduction of the item for the Patent Office by the sum of £100. He said he did this in order to advocate the redress of a grievance which was felt to be serious by the large and important class of inventors in this country. The fees were such as might be from time to time, with the sanction of the Treasury, prescribed by the Board of Trade. The initiative in reducing the fees rested with the Board of Trade, so that if there was a strong case for the reduction of these fees, and they were not reduced, the responsibility primarily rested with the President of the Board. The Chancellor of the Exchequer had admitted that the receipts of the Patent Office for the year 1889 were £93,534 in excess of the expenditure. The report for the year 1890, since issued, showed a large increase on that large sum—viz., £109,366. The Patent Office for the year yielded no less than £165,000; designs, £4,500; trade marks fees, £16,400; and the sale of publications, £6,000, making a total of £192,000; while the total expenditure of the Patent Office was only £83,240. The rigth hon. gentleman said that manufacturers did not object to fees which had the effect of extinguishing useless patents, and that it was in contemplation to spend a considerable sum on new buildings. The Chancellor of the Exchequer had been misinformed regarding the views of manufacturers. There had been memorials from manufacturers and inventors in Liverpool, Birmingham, Manchester, Leeds, and London, praying for a reduction of the fees. He had been almost overwhelmed with correspondence from all parts of the kingdom, urging him to persevere with this motion. The cost of a patent in this country was largely in excess of that in any other country in the world. The British Government exacted £154 for a patent for 14 years, against £7. 10s. in the United States for 17 years. Protection for four years cost only £4, but the payment of £100 for the fifth year brought that up to £14, being for five years about double the charge in the United States for 17 years. The Patent Office did nothing to ascertain or to guarantee the validity of a patent. On the other hand, the United States Patent Office for the £7. 10s. it received insured the patentee a real title by a painstaking examination by the best experts. Computing the fees for the number of years for which the patents existed in the different countries, the average charge in each country was as follows :—United States, 8s. 5d. per annum for 17 years; France and Italy, £4 per annum for 15 years: Belgium and Spain, £4. 4s. per annum for 20 years; Russia £5. 10s. per annum for 10 years; Great Britain, £11 per annum for 14 years. This country was far behind even Russia, our fees being 100 per cent. more than those in that benighted land, while they were 2,500 per cent. more than those in the United States. How far fees affected the number of patents was shown by the following returns for 1887, for Great Britain and the United States respectively :—Applications, 18,051—35,613; patents granted, 9,410—20,429; income from fees, £124,279—£228,902; expenditure, £81,577—£198,892; surplus, £42,702—£30,010; patent fund, none—£651,498. It thus appeared while the small fees encouraged the taking out of double the number of patents in the United States, the total amount of the fees was double that in this country, and a very large patent fund had been accumulated. This country, in effect, levied a heavy tax upon its inventors, on the men to whose ingenuity it was so largely indebted for its manufacturing and mercantile prosperity. The United States, on the other hand, made the smallest reasonable charge on the inventor, with the result that almost every American citizen was a patentee. America encouraged her poor newsboys, like Edison, to become distinguished inventors and millionaires, while the Patent Office in this country exacted fees which to many a poor man were prohibitory, and, although in many cases he might scrape together the £4 charged during the first four years, he was quite unable to pay the £10, £15, and £20 per annum exacted during the remaining 10 years. The right hon. gentleman the member for West Birmingham, when President of the Board of Trade in 1883, introduced a great improvement on the system which had previously existed. Under the Patent Act of 1852 the patent fee of £150 was required to be paid in two instalments of £50 and £100 respectively, which covered the patent for 14 years. Under the Act of 1883 the total sum of £154 was spread over 14 years in the following manner :—£1 was charged on filing the provisional patent, and £3 on its completion, so that for the first four years the total charge was only £4. Then from the end of the fourth year till the end of the seventh year £10 per annum had to be paid, for the next two years £15 per annum, and the next four years £20 per annum. These changes led to a large increase in the number of patents. Under the Act of 1852 the largest number of applications was in 1882, the total being 6,241, but immediately after the passing of the Act of 1883, which spread the fees over a number of years, the applications rose to 17,110, and they had gone on steadily increasing, until in 1889 the number was 21,008. The easier method of charging the fees, although the total fees

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remained the same, had led to an increase in the number of applications for patents of between 300 and 400 per cent. The reason why the renewal fees were left unaltered in their aggregate amount was, that it was feared that without these the administration of the Patent Office might be carried on at a loss, owing to the reduction brought about by the diminished fees. But now that it was plainly evident that there was no risk of such loss as was then feared, owing to the number of patents having increased fourfold through the easier method of paying the fees, the time had come to consider the question of renewal of fees *de novo*. Even if the fees were reduced, and reduced very considerably, there would not be a proportionate reduction of the total receipts of the Patent Office, but we should see that as the spreading of the fees over a number of years led to a large increase of applications, so would the lessening of the annual payments. Many more patents would be applied for, and many more payments made, which would compensate, to a large extent, for the reduction of the fees. No one would object to a reasonable and prudent expenditure in enlarging the Patent Office. The accommodation at present was miserable. The library was a limbo where inventors soon lost themselves and gave up searches in despair. Much might be done to improve the arrangements. A larger staff of compilers of abridgments should be employed, so that they might be brought closely up to date. The American system of examination should be adopted, to prevent duplicating and triplicating patents for the same invention. In some points the Patent Acts should be amended, especially in conformity with the valuable report made some time ago by the Chairman of the Chemical and Allied Trades Committee. With a surplus of £110,000 a year to work upon, the Patent Office might do much to encourage poor inventors by purchasing from them inventions of real utility, and making them free to the public. He did not contend for the total abolition of renewal fees, but he did say that to tax inventors £150 on each invention, in a country which had so much to gain from the encouragement of inventions, was most injurious, not only to the inventor, but to the country. A comparatively small annual payment during the currency of the patent should suffice, and either £3 or £5 per annum would be quite sufficient. The present system of transferring the annual surplus from the Patent Office to the Treasury was very objectionable. When so transferred, the money was lost sight of, and inventors were apt to forget how heavily they were being taxed. During the last five years these surpluses had amounted to fully £360.000. The Patent Office revenue ought to be distinctly ear-marked, and appropriated for the advantage of inventors, and not thrown hotch-potch into the general revenue of the country. It was extremely inconsistent on the part of the Government to grant large sums on the one hand, for technical education, and then, on the other, to tax those who were technically educated, and were turning their technical education to good account. We should not only endeavour to fetch up our leeway, so far as technical education was concerned, but we should adopt all the enlightened methods we could devise to stimulate and encourage inventors in all the arts and crafts which are the foundation of our manufacturing and mercantile preeminence. Instead of our Patent Office being a helpful promoter of inventions, it was a hard, niggardly, unsympathising tax collector, bent on screwing all it could out of the poor inventor, while aiding him as little as possible. In conclusion, he would respectfully urge the President of the Board of Trade, and his colleague, the Chancellor of the Exchequer, no longer to look at this question merely from the manufacturer or capitalist's point of view; no longer to look at it from the Treasury point of view as to how much the inventors of the United Kingdom could be made to contribute to the taxation of the country. Rather let them take the broader and more enlightened views which were suggested by reference to the grants in aid of technical education; by the representations which had been made in so many memorials, letters, and pamphlets in the interest of inventors, advocating the reduction of these renewal fees not merely for the benefit of inventors, but for the advancement of our trade and manufactures, the employment of our people, and the prosperity of the country at large.

Sir W. HARCOURT said a few words in support of the motion.

Sir M. HICKS-BEACH said that in this matter the first question which the Government had to consider was what they could afford to do. He did not suppose that the hon. member, or the right hon. gentleman, would argue that the cost of the Patent Office ought to be charged upon the general taxation of the country. Patentees, he thought, should certainly provide for the cost of the office. On the other hand, he did not think that the country ought to look upon the Patent Office as a permanent source of income. After the change introduced in 1883, when the Bill of the right hon. member for West Birmingham was passed, the gross receipts from the Patent Office sank to £88,000, the receipts previously having been much larger. The large increase in the sum derived from patent fees was a matter of very recent growth indeed, and in 1886 there was actually a deficit of £2,800 in connection with the Patent Office. The estimated surplus for 1891 was £116,500, and the Government contemplated very considerable expenditure for the benefit of the service. He had thought it right to examine thoroughly the buildings in which the work of the office was done, and any more inconvenient buildings, both for the gentlemen employed and the public, he had never seen. Complete reconstruction would be necessary, and it would cost fully £130,000. The money would be very well spent, because the rearrangement would facilitate a more efficient and economical administration of the office, and after the reconstruction the public, who frequented the office in large numbers, would have easier access to the specifications and to all the publications in the library. The expenditure would be provided for out of the surplus of the next two or three years. It was also very necessary to make more rapid progress with the work of the abridgment of specifications. Copies of the actual specifications were sent round to a certain number of public libraries, but only in very few places could they be turned to any public use. The public generally wanted abridgments, and to proceed with their preparation more rapidly would involve further expenditure, which must come out of the surplus from the Patent Office fees. The fact that this expenditure must be incurred being admitted, he was ready to acknowledge that there were grounds for considering whether something might not be done in the direction of the reduction of fees. It was not quite right to compare the fees charged here with those charged in the United States, and he, for one, would be very sorry to see the adoption in this country of the United States system, under which, by the payment of £7. 10s., a patentee could obtain protection for 17 years. It was his opinion that the right hon. member for West Birmingham introduced an admirable system by the Act of 1883, when he provided that protection should be given for four years on the payment of £4, and that if the patentee should require further protection he should be asked to make larger payments, year by year, until the total period of 14 years was completed. He thought that in any scheme of revision the system of making a small demand for the first years and of increasing the payment for the later years should certainly be adhered to. Comparison had been made between the total payment exacted in this country for 14 years—namely, £154—with the payment of £77 exacted in the United States. Ours, however, was not the highest payment required to be made, for in Germany the total sum paid for a protection of 15 years amounted to £265. It had been said that these patent fees constituted a tax upon invention. He denied that that was the fact when the payment was light for the first few years. A payment of £4 for four years could not be regarded as a tax upon invention. It was a lower payment than was demanded by any other European country for protection for a similar period. His view was that they should consider whether a reduction might not be made in the fees charged in the interval between four years and eight years, so as to extend the chief protection now given for four years to a considerably longer period. He did not believe that it would be to the advantage of the public, or even of inventors themselves, that patentees should retain patent rights with regard to patents which were not worked, and which were not likely to be worked. Such retention would be as great a hindrance to invention as anything that could be imagined. If a patent was not taken up in a period of seven or eight years, was it likely to be taken up at all? If it was taken up, the fees charged were trivial, as compared with the profits of the successful patentee. What had to be considered, then, was the position of the patentee who did not work his patent, and he thought that what should be done was to make the fees low for a certain number of years, during which the patentee could look about for opportunities to work his patent, but they ought not, by lowering the subsequent fees, to encourage him to retain his patent rights for a longer period. He trusted that the hon. member for Dundee would be satisfied with the statement which he had been able to make.

Mr. LENG expressed his gratification at the assurance given by the right hon. gentleman that he would consider the expediency of extending the period when low fees were charged. As to the proposed reconstruction of the Patent Office, he did not think that any one would grudge the expenditure.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *July* 8, 1891.

Electric Traction Motors.—Electrical news is rather scarce just now. The large companies are for the most part working hard, and business is excellent, although very little fuss is being made about the work that is accomplished. Electric railroad work is booming as usual, the Thomson-Houston Company alone producing motors at the rate of nearly a hundred a week. Practically, all of these motors are of the single reduction gear type brought out this last spring, and they have been meeting with very considerable success. The gearless motors of which so much has been said are being introduced fairly rapidly, although no roads equipped with them are at present completed. A few weeks, however, will see this condition of affairs changed, and it appears at present as if everybody was keeping quiet and waiting to see what the outcome of the gearless motor experiment will be. Among electricians the type meets with approval, though the general opinion seems to be that it will fail either in efficiency or in torque; in other words, that there is nothing sufficiently radical in the design employed to give the powerful torque necessary for work on steep grades without very seriously lowering the efficiency. Of course, for comparatively level roads this objection does not hold true.

The Electric Lighting Plants of the New Naval Vessels.—Some considerable difficulties have been met in fitting electric light plants to the new naval vessels; the gunboat "Concord," in particular, has been the source of considerable trouble. The plant installed was an Edison multipolar marine dynamo, with direct connected engines, and it worked in a rather unsatisfactory manner. The problem of ship lighting is by no means an easy one when space is so contracted as in a man-of-

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war, but one would suppose that by this time sufficient experience would have been gained in the dessigning of marine dynamos to avoid anything of a serious nature.

The Montreal Meeting of the National Electric Light Association.—Great preparations are being made for the meeting of the National Electric Light Association, in Montreal, the second week in September. There will be a fine display of electrical apparatus and appliances. All the large companies and most of the small ones will send exhibits, and will crowd the large hall that has been provided for that purpose to the uttermost. Besides this, the most hospitable preparations have been made by the Canadians for the reception of their visitors, and there is every probability that the coming Convention will be a great success. At the meeting in Providence, last February, a new and particularly active set of officers was elected, with the best results as regards the efficiency of the association.

PARIS NOTES.

(FROM OUR OWN CORRESPONDENT.)

PARIS, *July* 13, 1891.

On the occasion of the voting of the extraordinary credit of 5½ million francs for the Marseilles-Tunis and Marseilles-Oran cables, there was considerable divergence of opinion as to the manner in which the work should be carried out. The committee demanded that the cables should be manufactured and laid by the State, the Government proposing to put the work up to tender. In the end the Government had its way by 317 votes to 162.

The affairs of the Compagnie Continentale Edison do not seem very prosperous just at present. The *personnel* is being constantly changed. M. R. V. Picou, consulting engineer to the Company, has severed his connection with it. M. René Arnoux has been appointed works manager at Jury, and most of the staff have been or shortly will be altered.

The Société Générale des Téléphones continues its campaign against infringers of its patents. Since the recent judicial decision giving it the monopoly of the telephone transmitter and induction coil, the Company has made several raids on shops where infringing telephones were being constructed without proper licence. The Post Office authorities thereupon adopted the Roulez apparatus. The Company, not to be beaten, has now proceeded to impound all the Roulez instruments it can lay its hands on. Fresh litigation is, of course, inevitable.

The Industrial Exhibition at the Palais de l'Industrie will open in a month's time. Electricity will be very much to the fore. Several large firms are bent on demonstrating the advantages and uses of small electric motors. The gas interest are also exerting themselves, and a large amount of space has been allotted to regenerative lamps, gas engines, gas stoves, &c. The rival systems will have their stands facing one another on opposite sides of the hall. The manager of the electrical department is M. D. Augé, representative of the Khotinsky Lamp Company.

VIENNA NOTES.

(FROM OUR OWN CORRESPONDENT.)

VIENNA, *July* 13, 1891.

The proposed new trunk line between Vienna and Trieste is being pushed on, and the route is being surveyed. It has been decided to complete this line by 1892. The other trunk lines are being used more than expected; the Vienna-Prague line cannot satisfy the demands made upon it, and it is proposed to erect a second line next year. The receipts amount to as much as 900fl. on some days. Constant additions are being made to all exchanges in Austria. The Vienna Company and the Telephone Company of Austria have now over 8,000 subscribers, the Government about 1,500.

Fiume was splendidly lit up by the International Electric Company of Vienna on the occasion of the Emperor's visit to the British Fleet. The huge wheat elevator had very large lights, and looked like a monster beacon, and was also worked entirely by electricity. The search lights and electric arrangements of the British war ships were much admired; but the absence of the Sellner glow lamp signalling apparatus, introduced into the Austrian Navy some years ago after exhaustive trials, was commented upon. The Austrian Navy Department have recently created the posts of "Electro Engineers." First-class engineer, salary £300; second class engineer, salary £200; third-class engineer, salary £180; fourth-class engineer, salary £120.

In Vienna, the International Electric Company are introducing electric motors to the vast number of small master workmen employing from 5 to 20 men in the suburbs; they intend charging about 12 kreuzers (2½d.) per horse-power hour. The town of Zizkow, a suburb of Prague, is to be lit up by the electric light, and the concession has been given to Mr. Krizik, the inventor of the Pilsen-Joel lamp.

CORRESPONDENCE.

QUADRANT ELECTROMETERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to your criticism on the Paper on "Quadrant Electrometers," by Profs. Ayrton and Perry and Dr. Sumpner, in your issue of June 12th, we beg to state that we have lately turned our attention to the quadrant electrometer, and have been trying, under the guidance of Sir William Thomson, to simplify its parts and adjustments as much as possible. We have been led to do this mainly from the consideration that Sir William Thomson has provided in his series of direct-reading multicellular and other electrostatic voltmeters a much more convenient and less costly means of measuring potential above 40 volts, whether on direct or alternating circuits, than can be obtained by the *idiostatic* use of the quadrant electrometer. Our desire has been to recommend the use of these later direct-reading instruments for all measurements of potentials above 40 volts, and to reserve the quadrant electrometer mainly, as hitherto used *heterostatically*, with the jar kept at a constant potential by the replenisher, for the measurement of small differences of potential in the determination of capacities, insulation resistances, &c. In these uses of the instrument the objections mentioned in the Paper do not in any way interfere with its accuracy or convenience. As Prof. Ayrton and his colleagues have pointed out that the action of the supports of the lower part of the guard tube would interfere with the use of the instrument for certain purposes, we have, acting under Sir William Thomson's advice, arranged to dispense with these supports and the lower part of the tube altogether.

As regards the system of magnetic control mentioned in the Paper, a great deal of time was spent upon this by Sir William Thomson in some of the earlier forms of the instrument, but the system was abandoned, as it was found inconvenient in many respects. We have, therefore, always adhered to the present bifilar system of control, which is very convenient for all degrees of sensibility, is particularly well adapted for the highest degrees of sensibility, and is perfectly free from all disturbances from magnets or any other influences external to the instrument.—I am, Sir, &c.,

JAMES WHITE.

Glasgow, July 14, 1891.

ALTERNATING CURRENTS FOR TRAMWAY WORK.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I notice that it is being stated that M. Zipernowski has invented a combined system of utilising continuous and alternating currents with the idea of working an electric tramway in Vienna, the method being to carry a high tension alternating current from a distance, to drive a synchronising motor, which drives a continuous current dynamo to supply the motors of the tramcars.

Without in the least wishing to take away any credit due to M. Zipernowski, I wish to state that the working of the Buffalo City tramways from the Falls of Niagara in this way formed part of the scheme which I presented to the International Niagara Commission last year. As the Cataract Construction Company has not yet settled what, if any, electrical project is to be adopted at Niagara, I do not desire to make any further statement at present.—I am, Sir, &c.,

GEORGE FORBES.

Athenæum Club, July 13, 1891.

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LEGAL INTELLIGENCE.

City and South London Railway Company v. London County Council.

In the Court of Appeal, on Friday, the case of the City and South London Railway Company *v.* London County Council came before Lords Justices Lindley, Fry, and Lopes, in the form of an appeal by the London County Council from a judgment of Justices A. L. Smith and Grantham, sitting as a Divisional Court, setting aside an order by the Lambeth police magistrate directing the City and South London Electric Railway Company to pull down so much of their Kennington Park-road station as overstepped the general building line. It appeared that when the station was erected the jurisdiction under the Building Act was vested in the Metropolitan Board of Works, and that their sanction was not obtained for the erection of the works which the police magistrate had directed to be pulled down. The case raised certain questions affecting the private Acts of Parliament of all railway companies passing through London, one being whether the special powers conferred by such Acts cancelled the prohibition by the general Act of erecting buildings in front of the general building line without the consent of the local authority. The plaintiff Company, under Acts obtained in 1884 and 1887, took powers to construct an underground electric railway from King William-street to Stockwell, and to purchase various plots of land for the purpose of erecting stations. In Kennington Park-road they extended their station to the line of the pavement. The London County Council complained of this, and the magistrate held that it was not necessary for the purposes of the railway that any part of the station should be beyond the general building line, and ordered the demolition of that part which overstepped the building line That decision was reversed, and from that reversal the County Council now appealed. Mr. Lumley Smith, Q.C., and Mr. R. C. Green appeared for the London County Council in support of the appeal, while Mr. Finlay, Q.C., and Mr. W. Graham opposed it on behalf of the City and South London Electric Railway Company. Their lordships upheld the decision of the Divisional Court, and dismissed the appeal with costs.

TRADE NOTES AND NOTICES.

[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.]

NOW READY.—"THE ELECTRICIAN" PRIMERS (38 in all, Vol. I., 20; Vol. II., 18), in two volumes. Price per volume 2s. paper covers, 2s. 6d. cloth; post free, 2s. 2d. and 2s. 9d. respectively. Single copies, 3d.; post free, 3½d. Prospectus on application to the Publisher.

TENDERS INVITED.—The Burton-upon-Trent Town Council invite tenders for an efficient system of electric lighting for adoption in certain streets in the borough, and for the construction and erection of a central station for generating electricity, and for supplying and laying down the necessary electrical wires, insulators, &c. Further particulars will be found in our advertisement columns; and forms of tender, conditions, and specifications may be obtained on application to Mr. F. L. Ramsden, engineer, Gas Works, Burton-upon-Trent. Tenders have to be delivered to Mr. T. N. Whitehead, the town clerk, before 10 a.m. on Saturday, August 29th.

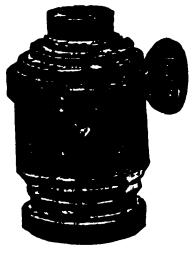
——— As will be seen by our advertisement columns, the Corporation of Salford invite tenders for lighting the Ladywell Sanatorium by electricity. Applications for specifications are to be made to Messrs. Maxwell and Tuke, or to Messrs. E. and F. Hewitt, architects, Manchester. Tenders must be addressed to the Chairman of the General Health Committee, and delivered to Mr. S. Brown, the town clerk, Salford, not later than 11 a.m. on Thursday, the 30th inst.

TENDERS ACCEPTED.—The tender of Messrs. Comyn, Ching and Co. has been accepted by H. M. Commissioners of Works for the pneumatic and electric bell hanger's work in the London district, at 25 per cent. off schedule prices for materials, &c., and 7½ per cent. on rates of wages in day work. The other tenders were:—Young and Buss, 37½ off, 15 on; C. E. Zimdars, 33⅓ off, 25 on; McClellan and Co., 25 off, 25 on; J. Defries and Sons, 20 off, 9 on; H. F. Joel and Co., 20 off, 15 on; J. and G. Odhams, pneumatic 10 off, 10 on, electric 25 off, 10 on; J. T. Mayfield and Co., 10 off, 10 on.

LISBURN.—The only tender received in response to the invitation of the Town Commissioners for estimates for lighting the town by electricity or gas, was from the Lisburn Gas Company, whose offer was 2s. 2d. per lamp, but the acceptance of the tender has been postponed, owing to the increase in the price.

SALE BY AUCTION.—Messrs. J. M. Klenck and Co. announce in our advertisement columns that they will sell by auction, at Storks-road, Bermondsey, S.E., on Thursday next, the 23rd inst., a saw-mill plant, machinery, &c., including a 25 H.P. horizontal steam-engine, a nearly new double furnace Galloway boiler, donkey pump, steam piping, 30 H.P. semi-portable engine and boiler by Davey, Paxman and Co., &c., &c.

THE PAISTE SWITCH.—Mr. Reyrolle, who is well known to our readers as the maker in this country of the Paiste Switch, sends us an illustration, which we give herewith, representing the switch inside an Edison lampholder. This is an ingenious and useful device. Of course the combination is made for export only. In addition to manufacturing this switch on a large scale, Mr. Reyrolle is an electrical and general engineer, maker of all kinds of electrical apparatus, switch boards, &c., &c., amongst which we may mention the one at the Metropolitan Electric Supply Company's Sardinia-street Station, which was recently fully described by Dr. Fleming in the columns of *The Electrician*.



ACORN AND EDISON SCREW KEY SOCKETS.—Messrs. Bayley Bros. ask us to notify that they are the original makers in this country of these key sockets, and are the only firm in the United Kingdom now making them.

ELECTRIC BLOWERS FOR VENTILATING STEAMSHIPS.—Messrs. Shippey Brothers inform us that they have secured the contract for fitting the new war ships, now being built in France for the Chilian Government, with "Standard Electric Blowers."

MESSRS. KING, MENDHAM AND CO.—On Thursday, last week, the *employés* of this firm had their annual outing at Ilfracombe, the party numbering between 60 and 70.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

June 3, 1891.

9,403. J. RAEBURN, junr. Glasgow. Improvements in electrically insulating appliances, known as "suspensions."

9,423. H. H. GRENFELL. London. An improved holder for electric incandescent lamps.

9,435. E. F. H. H. LAUCKERT. London. An electrical transformer.

9,436. A. D. WILLIAMSON. London. An electrical transformer.

9,437. J. VON PEICHL. London. Improvements in compasses with electrical appliances for signalling and recording the course and speed of a ship, also partly applicable to other purposes.

June 4, 1891.

9,462. A. W. ALCOCK. Manchester. An electro-static switch and phase indicator.

9,507. C. A. DAYTON. London. An improved electric stop motion for engines.

9,522. W. STANLEY, junr., and J. F. KELLY. London. Improvements in alternating current electro-magnetic motors.

9,524. W. STANLEY, junr., and J. F. KELLY. London. Improvements in methods of, and apparatus for preventing the interference with speech on telephone circuits by induced and other currents.

June 5, 1891.

9,555. J. E. A. GWYNNE. London. Improvements in carbons or electrodes for arc or other electric lamps.

June 6, 1891.

9,593. J. T. NEWELL. London. Advertising and illuminating by electric current.

9,606. W. P. THOMSON. Liverpool. Improvements in apparatus for holding telephone receivers, and for placing in or out of circuit either the call or the transmitting apparatus (S. Stein, junr., Germany).

9,627. C. D. ABEL. London. Improvements in thermo-electric batteries (R. J. Gülcher and the firm of J. Pintsch, Germany).

9,628. D. G. FITZGERALD. London. Improvements in or connected with negative elements (positive electrodes in charging secondary cells) of voltaic batteries.

9,629. D. G. FITZGERALD. London. Improvements in or relating to the negative elements (positive electrodes in charging secondary cells) of voltaic batteries.

9,637. H. ALABASTER and T. E. GATEHOUSE. London. An improved automatic electric control or cut-out.

9,639. W. C. LOVELACE. London. The better insulation of electrical conductors, and to obtain immunity from fire from the use o such conductors.

9,642. H. WATT. London. Improvements in and relating to electric lamps or lighting apparatus.

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June 8, 1891.

9,652. A. Watt. Balham. Improvements in the production of copper tubes by electrolysis.

9,683. T. J. D. Rawlins and A. Walker. London. Improvements in electric primary batteries.

9,689. P. Jeanty. London. Apparatus for supplying depolarising or other liquids to a series of electric batteries.

June 9, 1891.

9,734. W. Aldred. Sheffield. Improvements in dynamic electric machines.

9,762. S. C. C. Currie. London. Improvements in secondary or storage batteries.

9,779. M. F. F. Bellier. London. Application of vibrating tongues to produce automatic resistances in telegraph lines.

9,780. P. V. McMahon. London. An electric regulator.

9,791. J. Greenwood. London. Improvements relating to carbon electrodes for electrolytic and other purposes.

9,803. An improvement in galvanic batteries.

June 10, 1891.

9,817. A. R. Molison. Swansea. Improvements in apparatus for inducing electric sparks for gas lighting and like purposes.

9,868. J. Orme. London. Improvements in or connected with electrical signalling to and from trains.

9,876. D. C. Coombes and W. Rowe. London. Improvements in telegraph block systems of railway traffic control.

June 11, 1891.

9,915. J. Swinburne and H. S. Holt. Teddington. Improvements in electric measuring instruments, electric safety fuses, manufacture of incandescent lamps, telephone transformers, electric organs, transformer distribution, envelopes.

9,928. G. A. Schoth. London. Improvements in galvanic batteries.

June 12, 1891.

9,955. S. H. Holden. Birmingham. An improved electricity meter.

9,956. R. H. Housman. Bromsgrove. An improved electricity meter.

9,997. J. Armstrong. London. Improvements in pipes or tubes for conveying liquids and gases, and for protecting and insulating electric conductors, and for other like purposes.

10,016. A. G. Melhuish. London. A new or improved dynamo-electric motor or generator.

10,023. W. P. Thomson. Liverpool. Improvements in or relating to telegraph relays (R. O. Wickes, United States).

10,030. C. Rieger. London. An improved device for obviating sounds produced by the vibration of electric conducting wires.

June 13, 1891.

10,069. A. Hoster. London. Improvements in or relating to electric bells.

10,082. P. Jablochkoff. London. An improvement in voltaic batteries.

10,083. H. S. Keating. London. An electrical safety cut-out.

10,090. L. Graban. London. An improved process for the electrolytic production of aluminium.

June 15, 1891.

10,127. H. L. Manton. London. An electric device for indicating tabulated public information.

June 16, 1891.

10,175. J. Walker and J. Hampshire. Dewsbury. Electrical metronome or time beater or regulator, for musical and other purposes.

10,213. W. Wood. London. An improved auto-electro-magnetic clothing.

10,220. R. W. Barker. London. Improvements in brush holders for commutators for dynamo-electric machines. (J. H. Bartholomew. United States).

10,227. P. H. Holmes. London. Improved electrical conductor.

10,239. A. H. R. Guiley. London. Improvements in electrical block systems for railways.

June 17, 1891.

10,256. F. King and W. P. Mendham. Bristol. Improvements in apparatus for signalling by electricity.

10,260. A. Shiels and W. Elliott. Glasgow. Improvements in and connected with electric signalling and lighting in trains, said improvements being also applicable for telegraphic and telephonic communication.

10,280. W. I. Thompson. Liverpool. Improvements in devices for protecting the ears when using telephone receivers. (R. Kolbe and K. Lischka, Germany).

10,289. W. Greenhalgh. Leeds. Improvements in mechanism for actuating fans or punkahs by electricity.

10,302. C. R. Bonne. London. New or improved coin-freed or automatic electro magnetic induction apparatus. (Petsch, Kupka and Popp, Austria).

10,307. C. Coerper. London. Improvements in and relating to dynamo-electric machines and electric motors.

10,311. H. G. Watel. London. Improvements in electrically driven fans.

June 18, 1891.

10,347. D. Fitzpatrick. London. Improved electric battery.

10,364. A. B. Gill. London. Improvements in electrical switches

10,371. F. R. E. Branston. London. Improvements in the production of light and the generation of heat and electricity.

10,398. J. S. Lewis. London. Improvements in telephone transmitters.

June 19, 1891.

10,425. F. W. Dickenson. London. Improvements in or relating to means or apparatus for illuminating roundabouts and the like with electric light.

10,434. P. E. Singer. London. An electric metre.

10,451. W. Haywood and C. H. Driver. London. An improvement in posts for carrying electric lights and such like purposes.

June 20, 1891.

10,481. G. A. Cassagnes. London. Improvements in apparatus for synchronising electric telegraph instruments.

10,548. W. Sharrow. London. Improved apparatus for mechanically winding electrical wires.

10,554. S. Z. de Ferranti. London. Improvements in connection with the construction and working of transformers or converters.

June 22, 1891.

10,612. Siemens Bros. and Co. Ltd. London. Electrical transformers for rotary phase currents. (Siemens and Halske, Germany).

10,613. Siemens Bros. and Co. Ltd. London. Glow lamps for rotary phase currents. (Siemens and Halske, Germany).

June 23, 1891.

10,636. M. A. Weir. Kingston-on-Thames. Improvements in electric telegraph printing.

10,664. H. J. Harris. London. Improvements in or connected with the insulation of electrical conductors.

10,695. E. E. Angell. London. An improved method of and apparatus for heating metal bars or blanks by electricity, for forging and other purposes.

10,697. H. H. Lake. London. An improved method of and apparatus for protecting dynamo-electric generators and other apparatus from the effects of lightning. (The Thomson-Houston International Electric Company, United States).

10,703. H. C. Jobson. London. Improvements in the manufacture of the arms or attachments of telegraph poles for carrying insulators.

10,704. A. Douglass. London. Electric directing apparatus for use in cabs, carriages, or on boats, railway trains and the like.

June 24, 1891.

10,729. G. B. Lückhoff and E. H. Hungerbühler. London. Dynamo or electro-motor ring armature construction.

10,762. G. J. Cashmore. Birmingham. Improvements in call boxes or like electrical communicators.

10,778. J. A. F. Aspinall and H. A. Hoy. London. Improvements in electric arrangements and apparatus for locking railway signal and point levers, also applicable for other purposes.

10,787. G. A. Cannot. London. Improvements in materials for insulating electric conducting wires, and for carbons and incandescent filaments for electric lighting.

June 25, 1891.

10,821. W. Balch. London. Improvements in firing guns by electricity.

10,832. Woodhouse and Rawson United (Limited). London. Improvements in electrical transformers. (E. Preschlin, Germany).

10,838. W. Brew. London. Improvements relating to the lighting of trains by electricity.

10,839. W. Brew. London. Improvements relating to dynamo-electric machines, and to electro motors.

10,843. J. Ferrand. London. Improvements in apparatus for regulating electric currents.

10,860. R. J. Spreadbury. London. Improvements in means or mechanism for regulating the lighting intensity of electric lamps.

June 26, 1891.

10,894. C. V. Boys. London. Electrometers.

10,932. A. B. Gill. Lee. Improvements in apparatus for repairing commutators of dynamos.

10,933. A. B. Gill. Lee. Improvements in commutators of dynamo-electric machines.

10,934. J. A. Kingdon and A. B. Gill. London. Improvements in dynamo-electric machinery, and in the regulation thereof.

June 27, 1891.

10,939 H. A. Mavor, W. A. Coulson, and S. Mavor. Glasgow. Improvements in conductors for electric lighting, electric bell circuits, and like purposes.

10,969. W. Aldred. Sheffield. Dynamo-electric machines.

10,977. A. de Meritens. London. Improvements in galvanic batteries. [Date applied for under Patents Act 1883, Sec 103, 28th November, 1890, being date of application in France.]

10,978. Siemens Bros. and Co., (Limited). London. Improvements in insoluble porous anodes for electrolytical process. (Siemens and Halske Germany).

10,983. J. H. Nicholson and The Aurophone Company, (Limited). London. The electro medication belt or pad.

11,004. C. Rousseau. London. Improvements in and relating to the manufacture of plates for electric accumulators.

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June 29, 1891.

11,016. H. L. CALLENDAR. London. Improvements in armatures of dynamo-electric machines and electric motors.

11,048. W. C. JOHNSON and S. E. PHILLIPS. London. Improvements in the preparation and laying of electrical mains on the Brook's system.

June 30, 1891.

11,060. P. GIRAUD. London. Improvements in thermo-electric batteries.

11,075. B. J. B. MILLS. London. Electric meters. (H. M. Pilkington and R. S. White, United States).

11,082. SIR C. S. FORBES. London. An improved telephone combination.

11,093. W. J. SANDY and W. A. EASTER. London. A simple device for detecting a leakage to earth, principally adopted to isolated electric light installations.

11,108. T. COAD. London. Improvements in and connected with electric primary batteries.

11,113. F. W. LAHMEYER. London. Improvements relating to electro-motors, and to the transformation and distribution of electric currents.

11,118. A. M. CLARK. London. Improvements in electrical signals for steam vessels and analogous purposes. (E. W. Tucker and L. Katzenstein, United States).

11,120. R. A. Fressenden. London. Improved leading-in wires or conductors for incandescent electric lamps and the like. [Date applied for under Patents Act, 1883, sec. 103, February 18, 1891, being date of application in United States].

11,133. H. H. LAKE. London. Improvements relating to dynamo-electric machines and electric motors, and to apparatus connected therewith. (The Crocker-Wheeler Electric Motor Company, United States).

SPECIFICATIONS PUBLISHED.

1890.

9,061. DE FERRANTI and WRIGHT. Electric meters. (Price 11d)

9,246. RONCZEWSKI. Electro-magnetic separator. (Price 8d.)

10,736. OUDIN and KRATZ-BOUSSAC. Electric light fittings for medical purposes. (Price 8d.)

10,805. MILLS (Edison). Electric motors. (Price 11d.)

11,720. JONES and OTHERS. Electrical fuses. (Price 6d.)

12,013. SINCLAIR and MACKAY. Electric insulating compound. (Price 4d)

12,244. NEWTON (Swan.) Incandescent electric lamps. (Price 8d.)

12,383. SHEPARD. Electric lamps. (Price 8d.)

12,504. ALLAM. Incandescent electric lamps. (Price 6d.)

12,763. BUFFET. Electrical batteries. (Price 4d.)

13,491. HARNESS. Electric belts. (Price 8d.)

1891.

2,866. LAKE (Weston). Electrical measuring instruments. (Price 8d.)

4,099. AKESTER. Electric arc lamps. (Price 8d.)

5,067. LASSEN. Economic, &c., telegraphing. (Price 8d.)

5,637. BARKER (Farmer). Electric converters. (Price 8d.)

6,831. PARCELLE. Dynamo-electric machines. (Price 8d.)

7,715. WASHBURN. Storage batteries. (Price 6d.)

7,778. THOMPSON (Williams). Electric conductors. (Price 8d.)

7,970, WAHLSTRÖM. Distributing electric energy. (Price 6d.)

8,034. SHEPARD. Electric conductors. (Price 8d.)

8,136. CHRISTIANSEN. Electric car motors. (Price 8d.)

8,163. DEWEY. Electric railways. (Price 8d.)

COMPANIES' MEETINGS & REPORTS.

The Eastern Telegraph Company (Limited).

The thirty-eighth half-yearly ordinary general meeting of this Company was held yesterday, at Winchester House, Old Broad-street; Sir John Pender, K.C.M.G., presiding.

The SECRETARY (Mr. George Draper) read the notice convening the meeting, and the minutes of the last ordinary general meeting, which were confirmed.

The report of the Directors being taken as read,

The CHAIRMAN said that the receipts for messages during the six months ended March 31, 1891, amounted to £349,749, as against £348,624 for the corresponding period of 1890, showing an increase of £1,125. The total working expenses for the half-year amounted to £102,020, as against £98,477, an increase of £3,543. Included in these figures, however, was the item "special repairs to the Alexandria-buildings, £3,823," to which he referred at the last meeting. Several of the items showed an increase, while others showed a decrease. The general expenses in London were £9,503, against £8,726, or an increase of £777, the principal amounts being for advertising and stationery. The working expenses at stations amounted to £75,003, as against £72,677, or an increase of £2.326. The necessary increase in the number, and the additional pay and allowances granted to some of their foreign staff, to which he referred at the last meeting, accounted for the increase in salaries, rent, fuel, and light. The amount carried to maintenance ships' reserve fund was only £3,000, as against £5,000 in the corresponding half-year, the other portion having been contributed by those telegraph companies who had hired their ships during the half-year. All their ships were now in a thorough state of repair. The staff endowment assurance fund was £2,366, against £1,168, or an increase of £1,198. Up to the last year a certain number only of their staff had taken advantage of this assurance scheme. The Directors, however, after 10 years' experience of its working, were so convinced of the benefits it conferred on the staff that they urged the remainder to join, and he was pleased to say that nearly the whole of the staff were now contributing members. It was a most important thing for the *employés* of the Company. The expenses attending repairs and renewals of cables amounted to £53,144, against £47,320, or an increase of £5,824. On reference to abstract "C," page 7, of the accounts, full particulars would be seen of the work performed by their ships during the half-year. The chief expense had been incurred in connection with the Red Sea cable, laid in 1879. They had succeeded in the removal of all the known weak parts, and laid in new cable, and it was now believed that this line, which had been working since the formation of the Company, could still be kept efficient for a number of years, thereby increasing the security of telegraph communication in the Red Sea. After providing for all expenses and interest charges against revenue, they were able to recommend a final dividend at the rate of 5 per cent. per annum, and a bonus of 1½ per cent. for the year ended March 31st last, and carry £96,000 to general reserve fund, which amounted to £534,650, after the appropriation of £100,000, to the cost of Suez-Perim-Aden No. 4 cable. He thought they would agree with him that this was a very satisfactory state of things. At the meeting last July he showed them the necessity of laying a new cable in the Red Sea from Suez to Perim and from Perim to Aden, at a cost of about £250,000. At the general meeting, in January last, they were informed that, in anticipation of the largely-increased traffic with Australia, consequent on the reduction of rates between Europe and certain Australasian Colonies, they had decided to lay a triplicate cable between Aden and Bombay of such a capacity as would give them a considerable margin of carrying power to deal with any increase of traffic that might be at all likely to take place during the next few years. It had always been their policy to keep ahead of the carrying requirements of the Company, and it was satisfactory to be able to say that the encouraging results of the traffic since the reduction of the rates to Australia had fully justified the prompt action of the Directors. With the temporary assistance of the Eastern and South African Company, in which they held 59/60ths of the share capital, they would be able to meet the payments as they fell due to the contractors without, to a very large extent, disposing of their reserve fund investments. The financial transactions would take four years to complete, and it was estimated that at the end of that time their position would be that the additions would have been paid for, and the whole amount applied out of the reserve fund, the Eastern and South African Company would have been repaid, and their capital account would stand at practically the same figure as at present, provided, of course, that no further extensions of their system were considered advisable. It was hardly necessary for him to say that the Company would then be in a much better financial position than it was to-day. Having referred with satisfaction to the steadily growing South African traffic, and to the general efficiency of the whole of the Company's system of cables, he concluded by moving the adoption of the report and the payment of the dividend recommended on the preference shares and the bonus on the ordinary shares.

The MARQUIS of TWEEDDALE seconded the resolution.

The CHAIRMAN, in reply to Captain Goodsall, said that, by the advice of their engineers, the last Aden-Bombay cable was laid to the south of the existing one.

The resolution was then put to the meeting, and carried unanimously.

On the motion of Mr. GRIFFITHS, a vote of thanks was passed to the Chairman and Directors.

The CHAIRMAN having briefly acknowledged the vote, the proceedings terminated.

[*A full report of the meeting will appear in next week's issue.*]

The following is the report of the Directors of this Company for the half-year ended March 31st last, referred to in the above report:—

The revenue for the period amounted to £383,306. 18s. 2d., from which are deducted £102,020. 10s. 4d. for ordinary expenses and £53,144. 9s. 6d. for expenditure relating to repairs and renewals of cables, &c., during the half-year. After providing £2,274. 12s. 9d. for income-tax, there remains a balance of £225,867. 5s. 7d., to which is added £78,195. 6s. 5d. brought from the preceding half-year, making a total available balance of £304,062. 12s. From this amount there have been paid—

Interest on debentures and debenture stock	£28,274	13	2
Dividend on preference shares	20,474	3	1
An interim dividend of 1¼ per cent. on the ordinary shares	50,000	0	0
	£98,748	16	3

Leaving a balance of £205,313. 15s. 9d., from which £95,000 has been carried to general reserve.

The Directors now recommend the declaration of a final dividend for the year ended March 31st last of 2s. 6d per share, and a bonus of 3s. per share, amounting together to £110,000, both payable on the 16th instant, free of income-tax, and making, with the three previous payments on account, a total distribution of 13s. per share, or 6½ per cent. for the year, on the ordinary shares. The balance of £313. 15s. 9d., shown at the foot

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of the revenue account, is proposed to be carried forward to the next half-year.

The revenue includes £33,283. 4s. dividends and bonus for the half-year upon the Company's investments in the Eastern and South African, the Black Sea, the Direct Spanish, and the African Direct Telegraph Companies.

The agreement with certain of the Australasian Colonies for the reduction of rates between Europe and Australia having been concluded, the new rates were brought into operation on May 1st last, and the increase of traffic is encouraging.

The laying of the triplicate cable between Aden and Bombay, referred to in the last report, was completed by the contractors on April 19th last. The operations for duplicating the Suez-Suakin section, referred to in the last report, were successfully completed on April 10th last.

The Chili Telephone Company (Limited).

An ordinary general meeting of this Company was held at Winchester House, Old Broad-street, on Tuesday, under the presidency of Colonel R. Raynsford Jackson.

The SECRETARY (Mr. Edmund Petley) having read the notice convening the meeting, the report of the Directors was taken as read.

The CHAIRMAN: Gentlemen, I need not say much in support of the report, because all the main features of our business are fully dealt with in it. My object, however, will be to emphasise what is stated there, and, perhaps, to add to its clearness on one or two points I will ask those who have reports in their hands to look at page 7, and to the statement of figures there. You will find that the gross revenue of the Company has increased from £26,310 to £38,711, or 47 per cent., and that the working expenses have increased from £15,996 to £19,506 –only 22½ per cent. The cost of working, if you go through the calculation, you will find has fallen from 61 per cent. on the gross revenue to 50 per cent. The increase, therefore, of the gross revenue and the diminution in the ratio of the expenditure have led to an increase of the net revenue in Chili from £10,314 to £19,205, showing the very satisfactory increase of 86 per cent. These figures will make manifest the pleasing feature in the statements we have to put before you—that is, the great improvement in the value of our property in Chili, the increase in its earning power, and, the fact that, but for an adverse circumstance over which we have had no control, we should have been able to pay, wisely and prudently, a handsome dividend this year, in addition to adding a fair sum to the reserve. We have been obliged to diminish the profit made upon the working of £17,094 by £3,089, which is a reduction on the present value of our liquid assets in Chili due to the fall of exchange, that diminution being 25 per cent. If it had not been for that fall in exchange, our earnings would have been equal to 8½ per cent. upon our capital. You will remember that last year I expressed my regret that we were only able to pay to our shareholders 5 per cent., though, in our prospectus, we held out the hope that we should be able to pay a dividend of 6 per cent. So far as our enterprise is concerned, we should now be able to exceed very much the promise of our prospectus, but for the fact that our prosperity has been—I trust only temporarily—interrupted by the civil war in Chili. Before I touch further upon the consequences of the civil war, I wish to point out that there has been an increase in the number of our subscribers in Chili of 965, or 33 per cent. I will ask you now to turn your attention to the table of expenditure in the last sheet in the report, showing that we have spent during the year £35,136, and I wish to point out that 75 per cent. of that amount has been spent in Santiago and Valparaiso alone. It has been spent upon the entire reconstruction of the systems there, upon the assimilation with our own of the property we took over from the National Company of Chili, and upon trunk lines between the political and commercial capitals of Chili. This will be eventually of enormous value in the development of our system in those two towns. The civil war in Chili has affected us in a variety of ways. In the first place the President found it expedient to monopolise the use of our telephonic exchanges in the territory over which he maintains his rule, and we have received for the loss which we thus sustained a certain, but undoubtedly not an adequate, compensation. We trust that, when the civil war is over, we shall obtain ample compensation for all our losses arising out of the revolutionary war, from whichever party gains the ultimate ascendancy. In the territory under the control of the Congress party our subscribers have not been dispersed. We are still working our own exchanges, and what damage has been done to our property in Chili has been in those parts of the Republic where the actual battle has raged. What the loss will prove to be in the end we are unable to say, but it is satisfactory to know that we are entitled to compensation for it. Another consequence of the civil war has been the enormous fall in the exchange, which has gone further since the accounts were made up: and also the absence of all knowledge as to when the normal state of healthy government will be restored in Chili. Until then, we can form little idea of when and how far the cessation of the war will restore to us our subscribers and enable us to extend our operations as has been done in the past year. Our doubt upon these and other subjects has led us to the conclusion that, although we have earned what would, under ordinary circumstances, have enabled us to pay 7 per cent., it is wise not to declare a dividend. If the war should cease early, and if the position of affairs in Chili should then be hopeful and satisfactory, it is quite possible that we may, even at an abnormal time, declare a dividend, for there is nothing in our articles to prevent our doing so. I have confidence that the shareholders will regard the course which the Directors recommend to them as a wise and prudent one. The Company is soundly based, the shareholding body is a strong one, and I think our position is exactly one of those which justifies our thinking more of the future than of the present. I do not regard it as necessary, having touched upon these points, to do more than to ask you to pass the resolution which I now propose:—

"*That the Report of the Directors, with the Statement of Accounts to the 31st March, 1891, now presented to this meeting, be approved and adopted.*"

The VICE-CHAIRMAN (Mr. Thomas Greenwood) briefly expressed his pleasure at seconding the resolution.

The CHAIRMAN put the motion to the meeting in the usual way, and declared it carried.

Mr. GREENWOOD: The Chairman is so very well known (not only to you, but to the world at large) in all telephonic business, that I need only ask you to re-elect him to his seat on the Board, which he has admirably filled since the commencement of the Company.

Mr. ALEXANDER HENDERSON seconded the resolution, which was unanimously adopted.

On the motion of Mr. A. HENDERSON, seconded by Mr. E. E. VENABLES, Mr. Thomas A. Welton was re-elected auditor to the Company.

The CHAIRMAN then intimated that the business was concluded, and he thanked them for their attendance.

Mr. VENABLES proposed, and Dr. LEESON seconded, a vote of thanks to the Chairman.

The motion was unanimously agreed to.

The CHAIRMAN: I beg to thank you, gentlemen, and I hope that the next time we meet it will be under favourable circumstances all round, instead of only in one very important particular.

The proceedings then terminated.

Johannesburg Gas Company (Limited).

An extraordinary general meeting of this Company was held at the Cannon-street Hotel, E.C., on Wednesday afternoon, Mr. W. F. Lance presiding, "for the purpose of considering certain proposals for the dissolution of this Company, and the transfer of its assets and rights to a company, to be formed in the South African Republic, for the lighting of the town of Johannesburg by gas and electricity respectively; or, otherwise, for the purpose of considering proposals in connection with the acquisition by this Company of the said concession for lighting by electricity, and the increase, if necessary, of the capital of this Company, or the issue of reserve shares, in consideration for, or in connection with, the acquisition of the said concession for lighting by electricity; and for the purpose of adding to, repealing, or altering any of the provisions of the Articles, in such manner as may be found expedient in connection with the said acquisition, or otherwise."

The SECRETARY (Mr. Taffs) having read the notice convening the meeting,

The CHAIRMAN said that the object of the meeting had reference to the first portion of the notice which had just been read, namely, the consideration of a scheme in connection with the suggested dissolution of the Company, and the formation of a new company for the acquisition of the electric lighting concession for Johannesburg. After briefly reviewing the circumstances which have led up to the present position of the Company, the Chairman dealt with the subject of his journey to South Africa on behalf of the Company, and said that, on arriving at Johannesburg, he found that the electric lighting concession was about to be taken up by a syndicate, which would start it in a small way by raising funds sufficient for a plant of comparatively small dimensions, and so make a beginning, which they were able to do within a few weeks—that is to say, there was plant and machinery on the spot for the purpose, so that, had he allowed that to continue, the Company would have had a rival in the field before they were in a position to complete their gasworks. Therefore, under the instructions of the Committee, he took such steps as were open to him, and was enabled to secure, on favourable terms, this electric lighting concession from the original holders of it. In addition to this, they had obtained from the Government of the Transvaal Republic an extension of time for twelve months under the gas concession, but on the distinct condition that they were, in connection with the acquisition of the electric lighting concession, to place a few arc lights in some of the principal streets of Johannesburg. The Government insisted upon this in order to satisfy the public of Johnannesburg, who had, not unnaturally, been crying out for light for some time past. It was, therefore, necessary to authorise the construction of 10 arc lights, which they found could be put in within a week's time, and the order for these had been cabled out to Johannesburg, involving an expenditure of about £2,500. The terms on which the electric lighting concession had been obtained were the payment by instalments of £6,000 in cash, and £8,000 or less in shares, according to the capital of the new company to be created, which would have, under this concession, the monopoly of lighting the town of Johannesburg. The Chairman said he had gone carefully into the figures, and he was sure he was within the mark in telling them that they might safely calculate on a net profit of from £20,000 to £25,000 per annum, which would yield a dividend of upwards of 10 per cent. on a capital of, say, £200,000. Owing to the high price of coal at Johannesburg, the cost of producing the electric light would be little, if any, higher than gas. The Directors proposed to make gas the principal source of lighting, but they also proposed to supply the electric light where required, and in order to lay down the necessary installations for this purpose additional capital to the extent of £50,000 would be required. Various methods had been suggested for raising this money, but the scheme favoured by some of the principal shareholders was the issue of a further £50,000 worth of debentures. In conclusion, the Chairman, in order to obtain an expression of opinion from the meeting, submitted the following resolution, which he explained could not be made valid now as there were not two-thirds of the shareholders represented at the meeting:—

"*That this meeting approves of the dissolution of the Johannesburg Gas Company (Limited) and the formation of a new company as an English*

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company, to be called the Johannesburg Lighting Company (Limited), for the purpose of acquiring and working the concessions for lighting Johannesburg with gas and electricity respectively, such company to have a share capital and debenture issue together not exceeding £250,000, of which amount the debenture issue, bearing interest at 8 per cent. per annum, and forming a first charge upon the Company's undertaking, and assets shall not exceed £100,000; and it is hereby resolved that upon the registration of such company in England this Company be dissolved, and all its assets and liabilities transferred to the Johannesburg Lighting Company (Limited) in exchange for:—Debentures of the Johannesburg Lighting Company (Limited), £50,000 to be issued to holders of the existing debentures in the Johannesburg Gas Company and ordinary shares of the Johannesburg Lighting Company (Limited), for £65,000 to be issued to the holders of existing shares in the Johannesburg Gas Company (Limited), to be distributed by the Directors as liquidators in the proportion of one share in the Johannesburg Lighting Company for every two shares in the Johannesburg Gas Company (Limited)."

Mr. ANDREWS seconded the motion, which was agreed to, and the meeting was adjourned for a month.

Telegraph Construction and Maintenance Company (Limited).

A general meeting of the shareholders of this Company was held on Tuesday, at the offices, Old Broad-street. Sir George Elliot, M.P., presided.

The SECRETARY (Mr. William Shuter) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, you are aware that we have no accounts to render at these half-yearly meetings, and as regards the work carried out during the last six months, I may say briefly that we have been employed principally since the commencement of the year in completing contracts entered into in 1890—that is, in finishing the manufacture and in laying the Eastern Telegraph Company's cable between Aden and Bombay and the Eastern Extension Telegraph Company's cable between Madras and Penang. Both of these operations were successfully carried out in the months of March and April last. Our factories are still at work—that is, our cable factories, for we have other factories—in completing a contract for the Great Northern Telegraph Company. It is, of course, difficult to forecast with any certainty the prospects of future cable contracts; but we are able to say that our general current business continues to be satisfactory. You are aware that on this occasion, as well as on the occasion of our annual meetings, we never go into details, and we must hope that we shall continue that course which we have practised for the last 20 years, and receive your confidence in the belief that we are doing the best for you in a description of business the nature of which is such that we think its general administration should, in the interests of the Company, be left to the Directors as much as possible. We do not go into our accounts except once a year, and I trust that my observation as to what our policy is will commend itself to the general meeting, and to the shareholders as a body. That is the whole of the business.

After a short pause, and no shareholder rising to ask any question or to address the meeting, the CHAIRMAN added: That is the whole of the business, and it is pleasant for me to infer that my observations have been received with satisfaction by the shareholders.

The meeting then separated.

Edison and Swan United Electric Light Company (Limited).

The following is the report of the Directors to be submitted to the annual meeting, to be held at the Westminster Palace Hotel, on Tuesday next, July 21, 1891, at 12 noon:—

The Directors have the pleasure of presenting to the shareholders their report and the accounts for the year ending June 30, 1891.

The business of the Company has resulted in a credit balance of £72,905. 4s. 7d., out of which the Directors have appropriated the sum of £3,425. 14s. 8d. to meet loss on realisation of dynamo account, taken over at the amalgamation; and £12,371. 14s. 7d. has been absorbed by the payment of an interim dividend on the A shares, at the rate of 7 per cent. per annum, for the first six months of the year. The Directors recommend the payment of the following dividends on the A shares, free of income-tax, and to be distributed in accordance with Clause 87 of the Articles of Association:—

(*a*) At the rate of 7 per cent. per annum for the half-year ending June 30, 1891 (making 7 per cent. for the year),

(*b*) Three per cent. in completion of payment of arrears of cumulative preference dividend for the year ending June 30, 1885,

(*c*) Seven per cent. in payment of arrears of cumulative preference dividend for the year ending June 30, 1886,

which will absorb £47,719. 10s. 7d., leaving £9,388. 4s. 9d., which the Directors have carried to the reserve fund, in accordance with Clause 89 of the Articles of Association.

The Directors have granted licences to several electrical firms and companies to manufacture holders and sockets for incandescent electric lamps under the Company's patents. This branch of the business will increase as electric lighting increases, and will bring a satisfactory addition to the revenue of the Company.

Mr. J. S. Forbes and Mr. F. R. Leyland retire from the Board in rotation, and offer themselves for re-election as Directors. The auditors, Messrs. Welton, Jones, and Co., retire, and are eligible for re-election.

NEW COMPANIES REGISTERED.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—Registered by Ashurst, Morris, Crisp and Co., 17, Throgmorton-avenue, with a capital of £800,000 in £10 shares. Object: To adopt and carry into effect certain agreements expressed to be made between the Brush Electrical Engineering Company (Limited), the Laing, Wharton, and Down Construction Syndicate (Limited), and the City of London Electric Lighting (Pioneer) Company (Limited), of the first part, and the Company of the other part, to carry on in the City of London and in the district of St. Saviour's Southwark, District Board of Works, the business of an electric light company in all its branches; to carry on the business of electricians, mechanical engineers, suppliers of electricity for the purposes of light, heat, motive power, or otherwise, and manufacturers of and dealers in all apparatus and things required for or capable of being used in connection with the generation, distribution, supply, accumulation, and employment of electricity. The first subscribers are:—Sir D. L. Salomons, Broomhill, Tunbridge Wells; F. W. Reynolds, 73, Southwark-street, S.E.; E. Lucas, 40, New Broad-street, E.C.; Duke of Marlborough, 3, Carlton House-terrace; Earl of Suffolk and Berkshire, Charlton Park, Malmesbury; Alan Charteris, Lloyd's, E.C.; J. B. Braithwaite, jun., 27, Austinfriars, E.C. There shall not be less than three nor more than 10 Directors; the first shall be appointed by the signatories to the memorandum of association. Qualification, £1,000. Remuneration: For the years 1891 and 1892, £1,000 per annum; 1893, £1,500; 1894, £2,000; 1895, £2,500; 1896 and thereafter, £3,000; the same to be divisible.

PERKINS, GRAHAM AND CO. (LIMITED).—Registered with a capital of £10,000, in £50 shares, the objects including the construction, carrying out, and equipment of electric light, telephone, telegraph, and electric power supply works.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the past week amounted to £4,883.

CITY AND SOUTH LONDON RAILWAY COMPANY.—The traffic receipts of this Company for the past week amounted to £692.

CITY OF LONDON ELECTRIC LIGHTING COMPANY (LIMITED).—The prospectus of this Company has been issued this week, the objects being to undertake the electric lighting of the City of London and the district of St. Saviour's (Southwark) District Board of Works. The two Provisional Orders granted by the Board of Trade for lighting the City to the Brush Electrical Engineering Company (Limited), and the one granted to the Laing, Wharton and Down Construction Syndicate (Limited) are, subject to the consent of the local authority and of the Board of Trade, to be taken over by the new Company, which will thus acquire the right of supply of the electric light over the entire area of the City of London. The capital of the Company is £800,000, divided into 40,000 preference shares and 40,000 ordinary shares of £10 each; and applications were invited for the ordinary shares by the Exploration Company (Limited) and the Electric and General Investment Company (Limited). Sir David Salamons, Bart., is the Chairman of the Company, and the Board of Directors include the Duke of Marlborough and three other Directors of the City of London Electric Lighting (Pioneer) Company (Limited). The chief engineer is Major-General C. E. Webber, C.B.; and the secretary is Mr. J. Cecil Bull, 1 and 2, Great Winchester-street, E.C. The list of subscriptions opened on Wednesday, closing yesterday (Thursday) for London, and at 11 a.m. to-day (Friday) for the country.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company notify that the coupons on their Five per Cent. Debentures, due August 1st next, will be paid on and after that date at the banking house of Messrs. Glyn Mills, Currie, and Co., 67, Lombard-street, E.C. Coupons should be left at the bank three clear days for examination.

EASTERN EXTENSION TELEGRAPH COMPANY.—This Company announces the payment by warrant, on August 1st next, of the interest for the half-year ended July 1st instant, on their Four per Cent. Mortgage Debenture Stock. The transfer books will be closed from the 28th to the 31st July, both days inclusive.

EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY (LIMITED).—This Company announces the payment by warrants, on August 1st next, of interest for the half-year ended July 31st on their Four per Cent. Mortgage Debentures. The transfer books will be closed from July 28th to August 1st, both days inclusive.

GLOBE TELEGRAPH AND TRUST COMPANY (LIMITED).—A balance dividend of 4s. 6d. per share is proposed by the Directors of this Company, a sum of £1,876 being carried forward.

NATIONAL TELEPHONE COMPANY (LIMITED).—The Stock Exchange Committee have ordered the further issue of 8,250 shares, Nos. 438,985 to 447,234, and £70,000 Four and a-Half per Cent. Debenture Stock, to be quoted in the Official List.

SERIES ELECTRIC TRACTION SYNDICATE, LIMITED (IN LIQUIDATION).—A meeting of the shareholders is to be held at the offices, 11, Queen Victoria-street, E.C., on August 12th, at 2 p.m., to receive an account of the winding up.

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WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended July 10, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,363.

CRICKET.—EASTERN TELEGRAPH COMPANY *v.* KENNETH ANDERSON AND Co.—The third annual match between these companies was played on Saturday last, at Morley's Ground, Neasden, when the Eastern team was victorious by an innings and three runs. Mr. Kenneth Anderson presented a bat for the highest individual score, and a ball for the best bowling average. The former was won by Mr. Burke, who played a steady innings of 37; and the latter by Mr. Couper, with an analysis showing six wickets for 23 runs. Mr. Richardson, for the Eastern Company, carried out his bat for 35, and Mr. Couper for 32. Major Granger made a good defence for his side with 15, against the bowling of Messrs. Couper and Chisholm and the excellent fielding of Messrs. Draper and Hardie. Mr. Jack did his best to retrieve the fortune of his side, and by vigorous hitting ran up 50 in a short time, but the result, as shown below, was an easy victory for the Eastern Company. Score:—

EASTERN TELEGRAPH COMPANY.—Chisholm, c Granger, jun., b Gurney, 0; Cole, b Jack, 0; Burke, st Sloper, b Gurney, 37; Hardie, b Jack, 4; Robertson, b Jack, 0; Couper (captain), b Hedderwick, 32; Richardson, not out, 35; Draper, h w, b Gurney, 0; Gardner, b Sloper, 3; Hensman, run out, 8; M'Millan, b Jack, 2; Payton, c A. Gardner, b Stuart Anderson, 0; extras, 3—total, 124.

MESSRS. KENNETH ANDERSON AND Co.—First Innings: A. Gardner, b Couper, 2; Sloper, c Cole b Chisholm, 11; Hedderwick, c Richardson b Chisholm, 0; G. C. Hawes, c Chisholm b Couper, 4; Kenneth Anderson, b Chisholm, 0; Jack (captain), b Couper, 3; Gurney, b Chisholm, 6; J. Gardner, c Chisholm b Couper, 0; Stuart Anderson, c Hardie b Couper, 4; C. Granger, c E. Gardner b Chisholm, 2; Major Granger, b Couper, 15; Strudurm, not out 1; extras, 0—total, 48. Second Innings: A. Gardner, c Burke b Chisholm, 1; Sloper, c Hensman b Chisholm, 4; Hedderwick, c Richardson b Chisholm, 0; G. C. Hawes, b Chisholm, 0; Kenneth Anderson, b Chisholm, 3; Jack, c McMillan b Couper, 50; Gurney, run out, 4; J. Gardner, c Draper b Chisholm, 0; Stuart Anderson, c Richardson b Hardie, 0; C. Granger, c Cole b Chisholm, 2; Major Granger, c Gardner b Chisholm, 0; Strudurm, not out, 2; extras, 7—total, 73.

COMPANIES' SHARE LIST.

PRESENT AMOUNT.	AMOUNT OF SHARE.	LAST DIVIDEND.	NAME.	PREVIOUS WEEK'S PRICE, JULY 8.		Price Wednesday, July 15.		RATE PER CENT. YIELDED.	DIVIDEND DUE.	BUSINESS DONE DURING WEEK ENDING JULY 15.	
										Highest.	Lowest.
			TELEGRAPHS.					£ s. d.			
£1,300,980	Stock	12/0	Anglo-American	45	46	45½	46½	6 2 7	Jan., Apr., July, Oct.	46	45
£2,849,510	Stock	24/0	Do. Preferred	84	85	84	85	6 15 4	" "	85	84½
£2,849,510	Stock	..	Do. Deferred	10¾	11½	10½	11	..	..	11	..
£250,000	100	4%	African Direct, Telegraph 4% Debentures	98	101	98	101	3 19 3	January and July ..	98½	..
130,000	£10	3/0	Brazilian Submarine	11½	12	11½	12	7 1 8	Mar., June, Oct., Dec.	12	11⅝
£69,200	£100	5%	Do. 5 per Cent. Bonds	101	104	101	104	4 16 2	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103	107	103	107	4 13 6	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	103	107	103	107	6 6 2	April and October ..	..	..
16,000	10	8/0	Cuba Submarine	10½	11½	10½	11½	6 19 2	February and August	..	..
6,000	10	10%	Do. Preference 10%	17	18	17	18	5 11 1	" "	..	..
12,931	5	3/2½	Direct Spanish (£4 paid)	3⅜	4¼	3½	4	7 0 0	April and October..	3⅝	..
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	10⅝	10⅞	10½	10¾	6 10 3	Jan., Apr., July, Oct.	10¾	10⅝
400,000	10	2/6	Eastern	14¾	15	14¾	15	4 6 8	" "	15	14¾
70,000	10	6%	Do. 6 per Cent. Preference	15	15½	15	15½	3 17 5	" "	15½	15⅛
£1,200,000	Stock	6%	Do. 4 per Cent. Mort. Debenture Stock	106	109	106	109	3 13 5	May and November	106½	106
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 10 11	February & August	108½	..
250,000	10	6/6	Eastern Extension	15	15½	14⅞	15⅛	4 12 7	Jan.. Apr., July, Oct.	15½	15½
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock	105	108	105	108	3 14 1	February & August	108	106½
£85,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	101	104	101	104	4 16 2	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb.,1900	101	104	101	104	4 14 4	" "	..	..
180,227	10	2/6	Globe Telegraph and Trust	9½	9¾	9⅜	9⅝	5 3 10	Jan., Apr., July, Oct.	9⅛	9⅛
180,042	10	6%	Do. 6 per Cent. Preference	15	15½	15	15½	3 18 8	" "	15½	15⅛
150,000	10	8½% fr 90	Great Northern	18⅛	18⅝	18⅛	18⅜	4 10 8	Jan., April, and July	18¾	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105	108	105	108	4 12 7	March & September	..	..
17,000	25	37/6	Indo-European	39	41	39	41	4 11 6	May and November	..	..
38,848	10	5/0	London latino-Brazilian	6½	7½	6½	7½	6 0 0	" "	..	..
£100,000	100	6%	Do 6 per Cent. Debentures	106	109	106	109	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's	8	8½	8	8½	4 14 1	April and October..	8½	8
3,381	£100 Cert.	6%	Submarine Cables Trust 6%	115	120	115	120	5 0 0	" "	..	..
15,609	10	4/0	West African Telegraph	8	9	8	9	5 11 1	January and July ..	..	..
£281,400	100	5%	Do. 5 per Cent. Debentures	95	98	95	98	5 2 0	March & September	96½	95½
80,000	10	2/0	West Coast of America	3	4	3	4	..	January and July ..	..	..
£150,000	100	8%	Do. Debentures 8% 1902	97	102	97	102	7 16 10	June and December	101	..
88,321	10	9d.	West India and Panama	2½	2⅝	2½	2⅝	..	..	2⅝	2½
84,563	10	6/0	Do. 6 per Cent. 1st Preference	9¾	10½	10	10½	5 14 3	May and November	10¼	..
4,669	10	34/6	Do. 6 per Cent. 2nd Pref.	9	10	9	10	6 0 0	" "	..	..
61,683	15	9/0	Western and Brazilian	11¼	11¾	11	11½	7 10 11	" "	..	..
30,364	7½	1/6	Do 5 per Cent. Cumulative Preferred	6½	7	6½	7	5 7 3	" "	6⅞	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	4½	5	4½	5	..	..	..	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	104	107	104	107	5 12 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103	106	103	106	5 13 2	" "	105	104½
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117	122	117	122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bond	100	104	100	104	5 15 5	March & September	..	..
			TELEPHONES.								
224,850	14/0	0/4½	Consolidated Telephone Const. & Maintenance	1⅞	1⅞	1⅞	1⅞	7 9 4	May and November	..	..
220,000	£1	4·76	Oriental (11s. paid)	1⅞	1⅞	1⅞	1⅞	6 3 11	Yearly	..	..
438,984	5	6%	National	4⅜	5⅛	4⅜	5⅛	5 17 1	June and December	5⅛	4⅞
15,000	10	6/0	Do. 6 per Cent. Cumulative 1st Pref.	13	13½	13	14	4 5 9	" "	..	..
15,000	10	4/9⅜	Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd)	12½	12⅝	12½	13	3 14 1	" "	13	..
350,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd)	104	106	104	105	4 5 9	..	105½	104½
58,000	5	1/0	United River Plate	2½	3½	2	3½	..	January and July ..	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 8	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
1,000	£50	..	City of London Electric Lighting Shares (£50 pd)	36	37	60	62	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	4½	5	4½	5	..	..	..	..
5,322	£5	..	House to House Electric	4½	5½	4½	5½	..	..	..	..
30,000	£5	..	Liverpool Electric Supply (£3 paid)	2⅝	2¾	2⅝	2¾	3 13 1	..	..	..
111,000	5	..	London Electric Supply	2	2½	1⅞	2	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	9¾	10½	9¾	10¼	4 7 7	..	..	..
7,730	£5	..	St. James' and Pall Mall	6¾	7	6¾	7¼	..	..	..	..
..	..	7%	Do. 7% Preference	1¼	1½	3½	3¾	..	..	..	..
42,853	5	..	Westminster Electric Supply (£5 paid)	4¾	5¼	4¾	5¼	..	..	5⅛	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	..	Brush Electrical Engineering	2⅝	2⅝	2⅝	2⅝	..	..	2⅛	2⅛
69,996	2	1/1	Do. 6 per Cent. Preference	1⅝	1⅝	1¾	2	6 0 0	June and December	1¾	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	4	5	4	5	7 0 0	January and July ..	..	..
17,130	5	..	Edison and Swan United	..	..	..	..	..	..	..	..
45,000	10	6%	Electric Construction	3½	4½	3	4	..	..	3¼	..
70,000	2	10/0	Elmore's Patent Copper Depositing	3	3½	3½	4	..	..	3⅝	3⅞
20,000	5	..	Fowler-Waring Cables (£4 paid)	2	3	2	3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	19	20	19½	20½	4 17 7	February & August	19⅝	..
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	106	103	105	4 5 9	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	7½	8½	7½	8½	11 15 3	..	..	..
11,334	£10	5/0	Do. Preference	9½	9¾	9½	9¾	8 4 1	..	..	..
78,949	5	2/1½	Swan United (£3. 10s. paid)	4½	5	4½	5	6 19 10	May and November	4⅜	..
37,350	12	36,0	Telegraph Construction and Maintenance	45	47	44	46	5 4 9	March and July.....	45½	44
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101	104	101	104	4 16 2	January and July ..	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£3 paid)	2½	2⅝	2½	2⅝	..	..	..	..
..	£5	..	Do. Preference (fully paid)	3⅝	4⅛	3¾	4⅛	..	..	..	..
			RAILWAYS.								
50,000	£10	..	City and South London Railway	4	5	4	5	..	..	..	..

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THE ELECTRICIAN:

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NOTES.

With the exception of the Chelsea Order of 1886, which was passed before the creation of the London County Council, all the Metropolitan Orders contain a clause giving the County Council power to appoint "competent and impartial persons to be electric inspectors for the purpose of inspecting electric lines and works and of certifying meters." On the strength of the Order of 1886, however, the Chelsea Vestry petitioned against the insertion of the above clause in the Cadogan Company's Order, and in spite of a very forcible plea for uniformity and economy in this matter from the representative of the County Council, Lord Basing's Committee decided that Chelsea required different treatment to the rest of the Metropolis. For ourselves we fail to see that a case was made out for departing from the uniformity of the "Model Order," and we cannot help thinking that the question was considered rather from the point of view of Vestry *v.* Council than from that of the public good.

This week has witnessed the laying of the foundation stones of two Polytechnic Institutes (one at Battersea, the other at Chelsea), and the opening of a Technical and Recreative Institute at New Cross. The former have been talked about for a considerable time past, and will have a distinctly educational purpose. The funds for the erection of the Battersea Institute have been provided by three large donations, but the endowment is quite inadequate, and it is hoped that some City Company will come forward to help. The New Cross Institute, on the other hand, has been built, fully equipped, and substantially endowed by the Goldsmiths' Company—the one City Company that for many years past has not only devoted large sums of money, but has given great care and forethought in founding numerous schools and other institutions, and whose excellent example has been followed by the Drapers. In addition to its educational classes, the Institute at New Cross provides a variety of recreation in the shape of concerts, athletics, cricket, tennis, and the like.

While the messenger service which has been provided by the Postmaster-General has so far fulfilled the expectations of the Department that it is proposed to extend it to the whole country after August 1st, a private company which, though not first to provide messengers, was foremost in establishing electric call boxes, has apparently met with some disappointment. The Boy Messengers Company were selected by the Postmaster-General for an attack which resulted in the excellent compromise of the licence which they had begged for all the time. The District Messenger Company had meanwhile been spreading their ingenious call boxes broadcast, and asked neither rental nor payment for fixing. We get very little for nothing now-a-days, and not much for sixpence, and the offer to place these electric calls on the premises of anyone who would have them seemed too good to be true; and since it is only quite recently that several houses in Kensington to which the wires have been laid for months have been provided with call boxes, we imagined that they could not keep pace with an immense demand. But during this week a circular has been sent round saying that, owing to the limited demand for the services of the messengers, the Company is reluctantly compelled to ask for a subscription of one guinea a year in advance, but that it was proposed to refund this sum if three guineas' worth of business was transacted in the course of the year. The recipients of the boxes—one cannot call them subscribers—naturally protested against the proposed charge, and we understand that the circular has been withdrawn, and the rental will not apply to boxes which have been asked for up to the date of the circular. The service of this Company, as well as that of the rival Company, is extremely useful, and, in several respects, is preferable to that of the Post Office, and we hope that they will extend their respective systems; but the jump from nothing to one guinea a year *in advance* is a considerable one, and its remission, after the three guineas' worth of business, is a rather complicated expedient. Meanwhile, we understand that the Boy Messengers Company continue to supply call boxes free of charge.

We are glad to learn that the Electric Construction Corporation are about to put into practice the system of guaranteeing or maintaining their accumulators, which has on several occasions been talked about. The opponents of secondary batteries have, with good reason, urged that the cost of up-keep of these expensive luxuries is an unknown quantity. Various widely differing estimates have been made as to the probable life of the plates under the best conditions, and the definition of these conditions remained as vague as the cost of which it is a factor. The Corporation have decided to advance on the principle of insurance, and hope, by taking a considerable number of batteries under their care, to make the good contribute towards the extra cost of the bad. At the same time, they propose to make different terms for maintenance, according to the arrangements which are made for charging, and the kind of work done on discharge. We understand that they propose to send an

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expert to inspect the battery, the engine, and, probably, the attendant, and on the report to quote a price for the up-keep. For an important battery, such as at a central station, they hope to arrive at a charge of 8 per cent. per annum on the first cost. As a rule, the charge will be from 10 to 20 per cent. We understand that they are making arrangements for maintaining the accumulators at the Brighton station, and are in negotiation at Liverpool for tramway work. It will very greatly simplify the cost of electric traction if such a guarantee can be arranged, and if one penny per car mile will pay for the whole up-keep of the batteries, the working cost should be easily ascertained. For such work it is reasonable that the Corporation should desire, and, indeed, make it a condition, that the charging and the care of the cells in loading and unloading should be supervised by a man nominated by themselves. We hope that some such plan will be adopted by users of secondary batteries, for too often the plates are not renewed in time, and when once a battery gets into trouble the result is generally most unhappy. The careful inspection which is sure to take place if a contract for maintenance is made, should produce results tending to restore the confidence which has been much shaken of late.

THE extracts which we publish this week from Mr. TESLA'S lecture on alternating currents of very high frequency will be found instructive reading. The numerous experiments described are of great scientific interest, and in many cases suggest useful applications. The difficulties to be overcome before such currents can be utilised for engineering purposes are far too great to render their introduction on any large scale at all probable; but they may quite possibly be found advantageous for special purposes, such, for instance, as the production of ozone by means of the brush discharge. It is also possible that some of Mr. TESLA'S suggested developments with reference to illumination may in the future be profitably carried out, for the efficiency of the best known method of lighting is only a few per cent., and this may be increased in the manner described by Mr. TESLA, if a tolerably cheap converter can be found for transforming the alternating currents supplied to it into other currents of much greater frequency. Mr. TESLA'S condenser transformer appears to be an arrangement of this kind, and his experiments, as a whole, form the most practical realisation which has yet appeared of the idea of producing light as the direct result of alternating currents of great frequency. The experiments on the alteration of the character of the brush discharge as the frequency of the alternations was increased are very striking, and are likely to throw light upon the nature of flames. The great importance of displacement currents, and the diminished value of conduction currents, owing to impedance, when the alternations are very frequent, are also clearly brought out in many ways. It is this which explains one of the last experiments described, in which the carbon filament of a glow lamp remains quite dark while the rarefied gas surrounding it is brilliantly illuminated; and the fact that the electric glow is equally intense at the surface, both of sharp points and round knobs, can only be accounted for by assuming that the phenomenon is mainly attributable to condenser action.

MR. TESLA contends that his effects are chiefly electrostatic, but, as Prof. J. J. THOMSON very pertinently remarks in our correspondence columns this week, "it is advisable to have a clear idea of what we mean by electrostatic action" in connection with this subject. The word has, until lately, been confined to phenomena caused by steady electric stresses, and rapidly alternating electromotive forces, such as Mr. TESLA has been dealing with, should not be so referred to. When currents are alternating with great rapidity the electric and magnetic phenomena are so intimately connected that it is next to impossible to separate them, and from a theoretical point of view it is undesirable. In fact the two sets of phenomena cannot exist apart, and Mr. TESLA'S effects are "electrostatic" simply because he has only used apparatus which indicates the presence of alternating electromotive forces.

British Association.—We hear that Prof. Silvanus Thompson will lecture, during the Cardiff meeting, to the operative classes, on Electricity in Mining.

Notices of Application for Provisional Orders:—Paddington—Paddington and Bayswater Electric Light and Power Supply; London Electric Lighting Company.

University College, Bristol (Chemical Department).—The Session 1891-92 of this College begins on 8th October. Further particulars will be found in our advertisement columns.

Kingswood.—At the last meeting of the Local Board the question of the electric light came forward for final decision, and it was decided to accept the tender of Messrs. Parfitt, of Keynsham.

Hove.—The Hove Commissioners have adopted the report of the Electric Lighting Committee, which recommends the installation, under Mr. R. E. Crompton's advice, of the three-wire system with storage.

Huddersfield.—At the last meeting of the County Council, it was decided to accept the amended tender of the Brush Electrical Engineering Company for the installation of the electric light, at a cost of £20,640.

Brighton.—Notice has been received from the Brighton and Hove Electric Light Company of their intention to apply for a Provisional Order to authorise them to supply electricity for public and private purposes within the area of the Urban Sanitary District of Brighton.

St. Moritzbad.—The central station for lighting the three large hotels at St. Moritzbad, in the Engadine, started work on the 23rd ult. Power is derived from the Julierbach at Silvaplana, about three miles distant. A fall of about 600 feet is used to drive turbines which are coupled direct to three 160 H.P. Ganz alternators. The transmission is effected at a pressure of 3,000 volts, the line being run on oil insulators.

Electric Traction in Paris.—Our Paris correspondent writes us that a Committee of the Municipal Council has decided in favour of the construction of a subterranean electric tubular tramway from the Bois de Boulogne to the Bois de Vincennes, passing under the Boulevard Diderot, the Rue de Rivoli, the Place de la Concorde, and the Avenue des Champs Elysées. This decision is, however, he says, without much meaning.

Direct Spanish Telegraph Company.—A branch station of the Direct Spanish Telegraph Company, in direct communication with their cable system, was opened on the 20th inst. at the general offices of the Company, 280, Winchester House, Old Broad-street, where telegrams for Spain and the Canary Islands, Portugal and Gibraltar, the West Coast of Africa, South America, &c., can be handed in from 10 a.m. to 6 p.m.

Munich.—The following are some additional particulars relating to the municipal electric lighting scheme at Munich, to which we referred in our issue of May 8th. The river Isar is to supply the necessary motive power, viz., 2,200 H.P. Some 5¾ miles of streets will be lighted by 307 arcs, and the public and municipal buildings will absorb nearly 6,000 16 c.p. glow lamps. It is proposed to charge 1¾d. per 16 c.p. lamp per

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hour (about 2s. 6d. per B. T. unit), and 1s. 5½d. per arc lamp per hour.

Royal Alfred Aged Merchant Seamen's Institution.—The following resolution was unanimously passed by the Committee of this Institution on the 8th inst.:—"That, in consideration of the kind interest and powerful aid extended to this Institution by Sir James Anderson, a ward at the home at Belvedere be named 'The Submarine Telegraph Ward,' and that Sir James Anderson be requested to allow his name to be placed on the list of Vice-Presidents of the Royal Alfred Aged Merchant Seamen's Institution."

Telephone Cables in the City.—At the last meeting of the Commissioners of Sewers, Mr. Sayer presented a report of the Streets Committee relative to an application by the National Telephone Company to place a portion of their telephone cables beneath the public ways, the Committee stating that, in their opinion, it was inexpedient to give consent to the application of the Company to use the subsoil of the City until the contracts lately entered into for electric lighting purposes have been carried out. The recommendation was agreed to without discussion.

The Tudor and Correns Secondary Batteries.—A meeting was recently held at the Central Hall, Hamburg, at the invitation of the Berlin Electric Lighting Company, of about 40 persons interested in the electrical industry, amongst whom were representatives of the firms Schwarz, Kopf, and Co., the Allgemeine Elektricitäts Gesellschaft, Siemens and Halske, Müller and Einbeck; Professors Voller, Pinkert, and Kohlrausch. A Committee was appointed to carry out investigations as to the merits of the Tudor and Correns secondary batteries.

Funeral of Mr. Willoughby Smith.—The funeral of Mr. Willoughby Smith took place, on Wednesday, at Highgate Cemetery. The Institution of Electrical Engineers was represented by Prof. Crookes, Prof. Carey Foster, and Mr. F. H. Webb. Amongst those present were Captain Halpin, Messrs. E. Dickens, Clifford, T. Brown, Stevenson, and nearly 100 of the Telegraph Construction and Maintenance Company's Greenwich and Wharf-road staffs; Mr. Saunders, representing the Eastern Telegraph Company; Mr. Robert France, and many other friends of the deceased.

A Useful Formula.—The following is a simple formula for determining the insulation resistance between a dynamo circuit and its frame:—

$$R = \frac{E - \epsilon}{\epsilon} \times r,$$

where R = insulation resistance in ohms, E = the terminal E.M.F. of the machine, ϵ = the sum of the volts observed between the positive brush and the frame, and between the negative brush and the frame, and r = the resistance of the voltmeter, which must be very high.

Transmission of Power at Oyonnax.—A large and interesting transmission of power plant has been in successful operation at Oyonnax, in the east of France, since March, 1890. Power is obtained from a 1,750 H.-P. fall, five miles from the town, where two 105 kilowatt 2,000 volt Thury machines are coupled direct to two horizontal turbines. The current is transmitted on the three-wire system to two 120 H.-P. 1,800 volt motors, driving direct on to two 125 volt 600 ampere dynamos, which supply current to the town on the three-wire system. The commercial efficiency of this arrangement is said to be 76·2 per cent.

Thunderstorms.—Severe thunderstorms continue to occur in various parts of the United Kingdom. At the end of last week, Newcastle and the Hartlepools experienced a succession of storms. On Sunday, Leeds and Middlesborough were visited. On Tuesday, a heavy thunderstorm passed over Norwich. The centre of the disturbance lay over the northern side of the city, and, when at its height, the lightning struck the tower of St. Michael Coslany Church, dislodging the ball surmounting the vane and tearing into splinters the crocketed standard supporting it. As far as could be ascertained, the fabric of the tower was undamaged.

Magnetic Anomalies.—In a recent issue of *Nature*, M. Alfonso Sella, of Biella, referring to the discovery of very strong magnetic anomalies between Charkov and Kursk, in Russia, by General A. de Tillo (*The Electrician*, Vol. XXVI., p. 689), raises the question whether the values there observed are strictly local, or extend over a relatively wide area. It would, he says, be of great interest to know if, on moving, say, some metres away from a station, the declination and inclination hold the same value. If not, there is clearly some cause which acts at a short distance; but if constancy is observed a great step would be taken towards the settlement of the question as to the existence of strong variations common to a wide area.

The London Telephone Service.—A deputation, consisting of Colonel Raynsford Jackson and Captain Davies, attended at the London Chamber of Commerce, on Tuesday. They came for the purpose of requesting the Chamber to appoint a Committee to inquire into the whole question of the position of the telephone companies in regard to rates, efficiency of service, and statutory powers, with the view of assisting the companies to supply the public with a more efficient service. Representatives of the Telephone Association of London were also in attendance, and as these gentlemen acquiesced in the proposal for the appointment of a Committee it was determined that the Committee should be formed.

A Long Electric Line.—The Thomson-Houston Electric Company has just entered into a contract for the equipment of the San Francisco and San Mateo Electric Railway. The plant will at first consist of six 80 kilowatt generators and 30 cars, 15 of which are to carry two 15 H.P. motors, while the remaining 15 cars are to carry a 25 H.P. motor. It is anticipated that the first section of the line will be completed in October. This contract means that the Thomson-Houston Company will equip what is, perhaps, the nearest approach to a regular electric railway in America. The San Francisco and San Mateo Company has already obtained a concession for its line from San Francisco through the suburban towns of San Bruno, Millbrae, Ocean View, San Mateo, and Belmont, to Redwood City, a distance of 28 miles. An application has been made for an extension through the counties of San Mateo and Santa Clara to San Jose, a distance of about 52 miles from the city.

Electricity for Nurses.—The summer term at Grafton College, Fitzroy-square, has just concluded with an examination conducted by J. Russell Harris, M.D., W. E. Sumpner, D.Sc., Arthur Harries, M.D., and H. Newman Lawrence, M.I.E.E., and certificates have been awarded. One student, an M.D., has obtained high honours in electricity and electro-therapeutics, while another has passed in the second division "with credit." The Papers set and the practical examination together form a satisfactory test of the knowledge on anatomy, physiology, electricity, electro-therapeutics, and masso-therapeutics necessary for the intelligent performance of medical men's instructions in the treatment of disease by electricity and massage. Nurses so trained will not be likely to perpetrate the absurd and often dangerous mistakes made by many who profess ability to administer electricity or "apply the battery" as they say, and we think medical men cannot fail to appreciate the advantage of having ready to their hand nurses who know something about electrical applications to the body, and why and how they are performed.

The Chicago Exhibition.—The delegates to the chief Continental cities from the executive of the Chicago Exhibition were received on Monday at a special meeting of the Council of the Society of Arts, convened in their new capacity as a Royal Commission for the management of the British section of the Exhibition. The Attorney-General, as chairman of the Council, presided, and a large number of the members were present. The Hon. Benjamin Butterworth, the head of the delegation, in replying to the Attorney-General's speech of welcome to him and to his colleagues, gave an exceedingly satisfactory account of the state of the preparations, and said, among other things, that the inhabitants of Chicago had now provided funds to the extent of $12,000,000, and that they were determined to spare no pains to render the Exhibition a success.—At a Council meeting of the London Chamber of Commerce, on Tuesday, Sir Philip Cunliffe Owen introduced the deputation from the Chicago Exhibition. The chairman, Sir A. Rollit, promised that every assistance in the way of publicity should be given; and he agreed that British manufacturers should take the lead and hold the premier position at Chicago.

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Lead Covering for Cables.—We may conclude (says Mr. L. D. Bishop, in the *Electrical Engineer* of New York) that, under ordinary conditions, lead is practically a perfect, if not an everlasting, cable protector. It is no argument to say that lead will fail under conditions such as those of special and extra-ordinary chemical action, which would destroy any metal; but even there lead will hold its own, for the salts formed on the surface generally make a crust which prevents further action beneath it. The writer has handled lead pipes which were laid down in Pompeii more than 1,800 years ago. Some six years ago they were in use for conveying water, to all intents as good and sound as when laid. It may be objected that no parallel can fairly be drawn between lead pipes which have laid under ashes and scoria for 18 centuries, and those laid in our great modern cities, in conduits exposed to destroying gases and corroding effluvia, But it is a very fair comparison. Those pipes were laid underground long before Pompeii was buried, and, judging from appearances, the inference is unavoidable that dirt and filth flourished there in much greater luxuriance than even in that queen of dirty metropolises, New York.

The Photogenic Efficiency of Various Sources of Light.—In a recent communication to the Académie des Sciences, M. Witz gives the following figures relating to the comparative photogenic efficiency of various sources of light:—

Sources of Light.	Expenditure.	Calories transformed.	Intensity in carcels.	Calories per carcel-hour.
Stearine candle	10·5 grammes per hour...	110	$\frac{1}{6·5}$	716
Ordinary gas-burner	105 litres per hour.....	567	1	567
Regenerative lamp	35 litres per hour.....	189	1	189
Glow lamp	3·5 watts per candle.....	3·1	$\frac{1}{6·5}$	20
Arc lamp	4·5 watts per carcel	4	1	4

If we take the arc lamp as our standard the comparative efficiencies are as follows:—Arc lamp, 100; glow lamp, 20; regenerative gas-burner, 2·1; ordinary gas-burner, ·7; stearine candle, ·56.

Electric Lighting by Water Power.—The Pacific Wenstrom Electric Company recently installed an electric lighting plant at the Geysers Hotel in Sonoma County, California, which possesses, says the *Electrical World* of New York, some points of interest. A 24-inch Dodd water wheel was used under a head of 158 feet with a one-inch nozzle, no governor being used. The plant is located near the bottom of a deep ravine about 100 yards from the hotel. The curve of efficiency of the water wheel was used as a guide for over-compounding the dynamo, and the results obtained are somewhat remarkable. When the water gate was wide open readings were taken, which showed the following results: 60 lights, 750 revolutions, voltage at dynamo, 111; 30 lights, 910 revolutions, voltage at dynamo, 108; 1 light, 1,060 revolutions, voltage at dynamo, 106. The voltage at the hotel was practically constant. When the brushes were removed from the commutator the speed of the dynamo ran up to about 1,200. In the operation of the plant the water is turned on at about six o'clock, and the oil cups filled, and no further attention is given to the plant until it is shut down at about one o'clock, after seven hours' continuous running. The normal speed of the dynamo was 950 revolutions, but over-compounding brought the full load speed down to 750. The reason of the high efficiency of this type of wheel is said to be due to the shape of the buckets. The feature of the new bucket consists in curving the corners of the bucket down, so as to partly surround the nozzle. The effect is that the water is discharged below the line of impact. With other wheels, the water is discharged upwards toward the axis of the wheel, and interferes with the succeeding buckets.

The Insolubility of Pure Metals in Acids.—The results of an investigation concerning the cause of the insolubility of pure metals in acids are contributed by Dr. Weeren to the current number of the *Berichte*. De la Rive, so long ago as the year 1830, pointed out that chemically pure zinc is almost perfectly insoluble in dilute sulphuric acid. Dr. Weeren's theory of the phenomenon is as follows: "Chemically pure zinc and also many other metals in a state of purity are insoluble or only very slightly soluble in acids, because, at the moment of their introduction into the acid, they become surrounded by an atmosphere of condensed hydrogen, which under normal circumstances effectually protects the metal from further attack on the part of the acid." The experiments from which this theory has been derived were briefly as follows. The amount of chemically pure zinc dissolved by the acid was first determined. It was next sought to determine what difference would be effected by performing the experiment *in vacuo*, when of course the escape of the hydrogen would be greatly facilitated. The solubility was found under these circumstances to be increased sevenfold. Next the experiment was performed at the boiling temperature of the dilute acid, first when ebullition was prevented by increasing the pressure, and secondly when ebullition was unhindered. In the first case, when ebullition was prevented, the solubility was practically the same as in the cold; while in the second case, with uninterrupted ebullition, the solubility was increased 24 times. Finally, experiments were made to ascertain the effect of introducing into the acid a small quantity of an oxidising agent capable of converting the hydrogen film to water. When a little chromic acid was thus introduced the solubility was increased 175 times, and when hydrogen peroxide was employed the solubility was increased three-hundred-fold. The explanation of the ease with which the metal becomes attacked when the ordinary impurities are present is that the hydrogen is not then liberated upon the surface of the zinc, but rather upon the more electro-negative impurities, leaving the pure zinc itself open to the continued attack of the acid.

The Goolden-Atkinson Separator.—Amongst the machines shown at the recent meeting of the Royal Agricultural Society, at Doncaster was a magnetic separator, intended to remove bolts, nuts, nails, horse-shoes, &c., from bones, oilcake, or minerals, before they are passed into disintegrating machines. The chief difficulties that had to be overcome in designing this machine were the large size and irregular shapes of the material to be treated, the fact also that the iron—particularly in bones—is frequently entangled in the bones, so that merely passing the substance *once* over or on to a magnet was not found sufficient to ensure the absolutely certain removal of the foreign substance. These points have been satisfactorily overcome by the use of a hollow truncated cone with 10 internal magnets of alternately opposite polarity. The cone revolves on outside runners, driven by friction only, which is found ample for the purpose. The bones are fed into the back end by a shoot, and, falling to the bottom, are rolled over and over again, so that, as they gradually travel forward—in about 10 or 15 complete revolutions—to the front, they pass 100 to 150 times over the magnets. In the upper part of the barrel is a fixed tray, into which the iron is carried and collected. Each magnet in turn, as it comes to the bottom, is magnetised, and remains so till it reaches the top, where it becomes demagnetised, and the iron is detached. This process is carried out by a commutating ring on the back of the machine, and the arrangement is such that each coil has one end permanently connected to one pole of the dynamo, and the other ends are in turn connected during one-half a revolution to the other pole. Thus the magnets receive current in parallel. Before cutting a coil out of circuit it is short-circuited through a resistance, and by this means no sparking of any consequence occurs. The machine has proved itself a very practical success, and the value of the repeated revolutions over the magnets has been demonstrated by many trials. The power required to excite the magnets is about 600 watts for the largest size, capable of dealing with four tons of bones per hour. The machine was exhibited by the Hardy Patent Pick Company, of Sheffield, and was manufactured by Messrs. W. T. Goolden and Co., under the joint patent of Messrs. L. and C. Atkinson and G. W. Elliott.

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MAGNETISM IN IRON AND OTHER METALS.*—XLV.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 267.*)

§ 156. **Ring Magnet with an Air Gap.**—We shall next consider a magnetic circuit consisting of a uniform iron ring, in which a narrow radial crevasse has been cut. When the ring is magnetised there is some leakage of lines of induction through it sides into surrounding space, especially near the crevasse, but most of the lines jump directly across the crevasse. We may conceive the magnetic circuit of the ring to be completed—though not quite perfectly—by a plate of air filling the crevasse, of the same area of cross section as the ring itself. The lines of induction spread somewhat in crossing the crevasse, and a closer approximation to the condition of a perfect circuit would, therefore, be reached by supposing the plate of air to have an area of cross section rather larger than the cross section of ring, the extent of this enlargement being dependent on the thickness of the crevasse. In the case which we postulate, however, the crevasse is very narrow, and it will suffice to take its area of section as no more than equal to that of the ring. Let s be the area of section, l the mean length of the complete ring (before the crevasse is cut), and δl the (small) mean thickness of the crevasse. Let the ring be magnetised, as before, by a coil of N turns, carrying a current C. The permeability of the ring is μ, and that of the gap is unity. Then,

$$\text{Flux} = \frac{\text{magnetomotive force}}{\text{magnetic resistance}} = \frac{4\pi C N}{\frac{l-\delta l}{\mu s} + \frac{\delta l}{s}} = \frac{4\pi C N \mu s}{l + \delta l (\mu - 1)}.$$

If there had been no gap, the flux would have been $\frac{4\pi C N \mu s}{l}$.

The effect of removing a short length, δl, of the iron, and substituting air as the material through which the magnetic circuit is completed, is to increase the resistance of the circuit as much as it would be increased by the addition of a length of iron equal to $\delta l (\mu - 1)$.

§ 157. **Comparison of a Split-Ring with an Ellipsoid.**—It is interesting to compare the case of a ring in which there is a gap with that of an ellipsoid of finite length.† In the ellipsoid, as we have already seen (§ 26), the free magnetism produces a self-demagnetising force, which is proportional to the amount of magnetisation, and opposes the action of the magnetising coil. If we call H the true magnetising force acting on the metal, and H' that part of the magnetising force which is due to the action of the coil alone, then

$$\mathsf{H} = \mathsf{H}' - \mathsf{N}\,\mathsf{I},$$

where I is the intensity of magnetisation, and N is a numerical factor, the value of which depends on the relation of the length of the ellipsoid to its transverse dimensions. We shall see that a precisely similar formula may be obtained for the ring with a gap by treating it as a nearly perfect magnetic circuit.

Since the magnetisation of the cut ring is very nearly uniform, the actual magnetic force in the iron, which is the resultant of that due to the coil and that due to the free magnetism, must also be very nearly uniform. Call this force H, and call H' the magnetising force due to the coil alone, which (on the supposition that the coil is uniformly wound) is $\frac{4\pi C N}{l}$.

Then $$\mathsf{H} = \frac{\mathsf{B}}{\mu} = \frac{\text{Flux}}{\mu s} = \frac{4\pi C N \mu s}{\{l + \delta l (\mu - 1)\}\mu s} = \frac{4\pi C N}{l + \delta l (\mu - 1)};$$

and $$\mathsf{H}' = \frac{4\pi C N}{l}.$$

Therefore, $\mathsf{H}' l = \mathsf{H}\{l + \delta l (\mu - 1)\}$,

$$\mathsf{H}' = \mathsf{H}\left\{1 + \frac{\delta l}{l}(\mu - 1)\right\},$$

$$= \mathsf{H}\left(1 + \frac{4\pi\kappa\,\delta l}{l}\right),$$

since $\mu = 4\pi\kappa + 1$.

Hence, $$\mathsf{H}' = \mathsf{H} + \frac{4\pi\delta l}{l}\mathsf{I},$$

or, $$\mathsf{H} = \mathsf{H}' - \frac{4\pi\delta l}{l}\mathsf{I}.$$

The factor $\frac{4\pi\delta l}{l}$ therefore take the place of the factor N in the formula for ellipsoids. Its magnitude depends on the proportion of the width of the crevasse to the whole length of the circuit.

Taking the case of a circular ring, this proportion may be expressed by reference to the angular aperture of the crevasse, that is to say, the angle subtended by the crevasse at the centre. Calling this angle α in degrees, $\frac{\delta l}{l} = \frac{\alpha}{360}$ and $\mathsf{N} = \frac{4\pi\alpha}{360}$.

The following table has been calculated by Du Bois, to show what aperture of crevasse in a circular ring produces the same self-demagnetising force as exists in ellipsoids of certain stated elongations :—

Ratio of Length to Diameter of Ellipsoid.	Factor N.	Equivalent Aperture in Circular Ring (degrees).
20	0·0848	2·41
30	0·0432	1·22
40	0·0266	0·76
50	0·0181	0·52
100	0·0054	0·15

It is scarcely necessary to add that the self-demagnetising force which is introduced by the presence of the crevasse affects the residual magnetism of the ring as well as the induced magnetism, precisely as it does in the ellipsoid. When the magnetising-circuit of the split-ring is broken, the residual magnetism causes a reversed force to act on the metal, the value of which is $\frac{4\pi\delta l}{l}\mathsf{I}_r$, where I_r is the residual intensity of magnetism. This prevents the residual magnetism from being nearly so great as it would be were the ring complete—indeed, a very narrow crevasse is sufficient almost wholly to destroy the (otherwise very great) residual magnetism of a soft iron ring. For example, in a ring of soft annealed iron, which, when uncut, retains, after being strongly magnetised, a residual induction, B_r, of 12,000 units, the presence of a gap only half a degree wide will reduce the residual value of the induction to about 1,000.

§ 158. **Graphic Representation of the Influence of a Narrow Gap.**—The influence of a narrow gap, both in resisting magnetisation and in promoting demagnetisation, is best seen by resorting to the graphic construction which has been already explained in relation to ellipsoids and long rods (§ 48). Let a, a, a (Fig. 132) be curves of magnetisation (curves of I and H) for the iron of the ring. Find the factor N, equal to $\frac{4\pi\delta l}{l}$, and draw the line O A, so that A M (drawn parallel to the axis along which H is measured) shall be to O M as $\frac{4\pi\delta l}{l}$ is to I. Then the intercepts between O M and O A represent the values of the self-demagnetising force, due to the corresponding values of I, and if we wish to represent the relation of the magnetism to the magnetising force produced by the coil alone (the force which has been called H' above), we have only to draw a diagram in which the lines a, a, a are sheared into the position b, b, b by taking the abscissas from O A instead of from O M, or, in other words, by adding $\frac{4\pi\delta l}{l}$ to H in every case. Thus, any point P′ in the new curve is found from the corresponding point P by taking P′R = PR + QR. The residual magnetism, which was O S in the ring without a gap, is reduced to O S′ in the ring with a gap. If the object of the construction had merely been to find the residual magnetism, O S′, that could have been done more readily by drawing O T inclined at the same angle as O A, but on the other side of the axis of I, to meet the descending curve a, and projecting S′ from the point of

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† See a Paper by H. E. J. G. Du Bois, *Phil. Mag.*, Vol. XXX., 1890, p. 335.

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intersection of O T with the curve. The same construction will, of course, serve to find the residual magnetism of ellipsoids, or of long rods, which may be treated as approximating to ellipsoids.*

In Fig. 132 we have supposed that the magnetisation of the iron is exhibited by means of a curve of I and H. If, instead of this, the curve of B and H were given, a similar graphic construction would still serve to show the effect of the gap. Since $\mathsf{I} = \frac{\mathsf{B}-\mathsf{H}}{4\pi}$, the self demagnetising force $\mathsf{N}\,\mathsf{I} = \mathsf{N}\frac{(\mathsf{B}-\mathsf{H})}{4\pi}$, which, in a very permeable substance like iron, is practically equal to $\frac{\mathsf{N}\,\mathsf{B}}{4\pi}$, since B is very great compared with H. Substituting for N its value $\frac{4\pi\,\delta\,l}{l}$, this becomes $\frac{\mathsf{B}\,\delta\,l}{l}$. The line O A has, therefore, to be drawn, in a diagram of B and H, at such an inclination that when O M represents B, M A is $\frac{\mathsf{B}\,\delta\,l}{l}$.

From the equation $\mathsf{H} = \mathsf{H}' - \mathsf{N}\,\mathsf{I}$, by substituting $\frac{\mathsf{B}-\mathsf{H}}{4\pi}$ for I,

we have $$\mathsf{H} = \mathsf{H}' - \frac{\delta\,l}{l}(\mathsf{B}-\mathsf{H}),$$

or $$\mathsf{H}'\,l = \mathsf{H}(l-\delta\,l) + \mathsf{B}\,\delta\,l.$$

$\mathsf{H}'\,l$ is $4\pi\,\mathrm{C\,N}$; it is the line integral of the magnetic force taken round the whole circuit, or, in other words, the magnetomotive

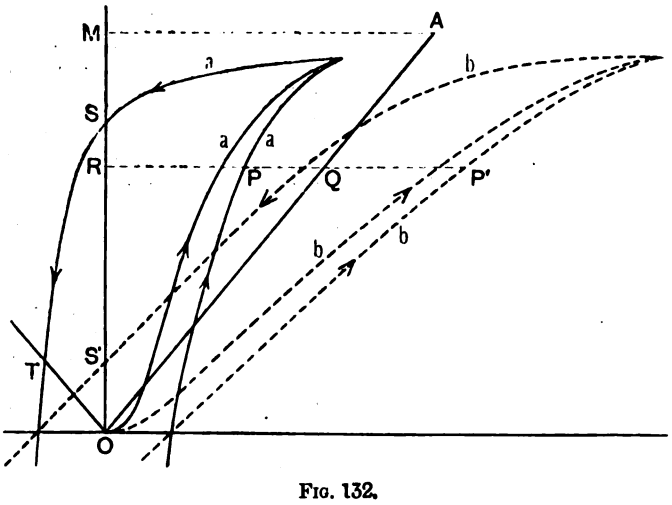

Fig. 132.

force. H is the magnetic force in the iron, and $\mathsf{H}(l-\delta\,l)$ is that part of the line integral which is taken through metal. B is equal to the magnetic force in the gap, and therefore $\mathsf{B}\,\delta\,l$ is that part of the line integral that is taken through air. The equation might evidently have been written down directly; it expresses the simple fact that the line integral for the complete circuit is made up of two parts, in one of which—namely, the iron, whose length is $l-\delta\,l$—the magnetic force has the sensibly uniform value H, while in the other—namely, the one whose length is $\delta\,l$—the magnetic force has the sensibly uniform value B. We have derived it otherwise, in order to accustom the student to observe the connection between the treatment of the ring as a magnetic circuit and that other treatment which deals with the magnetic condition at individual points. In the language of the magnetic circuit, $\mathsf{H}(l-\delta\,l)$ represents that part of the whole magnetomotive force which is used up in overcoming the magnetic resistance of the iron, and $\mathsf{B}\,\delta\,l$ represents the remainder of the magnetomotive force, which is used up in overcoming the resistance of the gap. In soft iron, if the gap is of any considerable width, its resistance is so great compared with that of the ron that nearly the whole magnetomotive force is used in forcing the induction across the gap.

§ 159. **Graphic Representation of the Relation of Flux to Magnetomotive Force.**—In dealing with the magnetic circuit as a whole, it is convenient to modify and generalise the graphic construction exemplified in Fig. 132, by drawing the abscissas to represent the whole magnetomotive force, and the ordinates to represent the whole magnetic flux in the manner first described by J. and E. Hopkinson.* Such a curve may obviously be derived for any part of a magnetic circuit from the curve of induction and magnetic force for the material by multiplying the induction by the area of section s to find the whole flux, and by multiplying the magnetic force by the length of the piece to find the magnetomotive force required for the magnetisation of that part of the circuit. Then, by graphically summing the abscissas for successive parts of any composite magnetic circuit, the whole magnetomotive force is represented in relation to the flux. An example will make the method intelligible. Take, as before, the case of an iron ring of uniform section with a gap in it, the length of the gap being $\delta\,l$, and that of the iron $l-\delta\,l$. From the curve of B and H for the metal of which the ring is formed—which we suppose to be known—draw the curve O P (Fig. 133), for the iron, in which any ordinate, P p, is the flux, B s, and the corresponding abscissa, O p, is $\mathsf{H}(l-\delta\,l)$. Next draw the curve O Q for the gap, in which the ordinate Q q is again B s, and the corresponding abscissa O q is the magnetomotive force required *for that part of the circuit*, namely $\mathsf{B}\,\delta\,l$. The line O Q is evidently straight, as it relates to a non-magnetic substance in which induction is proportional to magnetic force. Then draw the resultant curve O R, in which for each ordinate the abscissa is the sum of the abscissas of the curves already

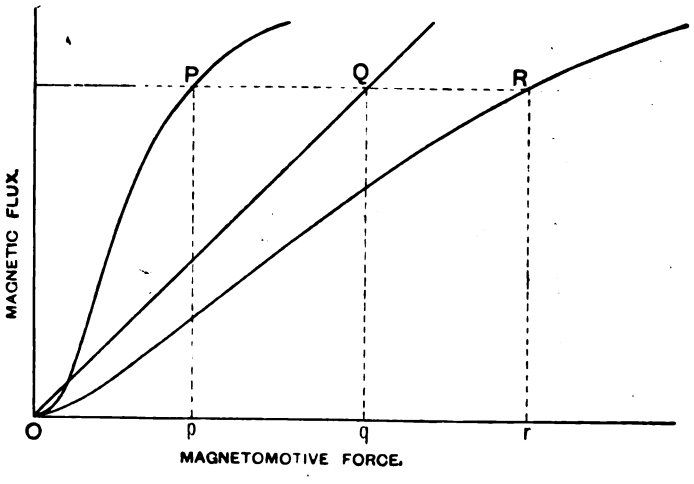

Fig. 133.

drawn, namely, O r = O p + O q. O r is the magnetomotive force required for iron and gap together, and the curve O R shows the relation of the flux to the magnetomotive force in the circuit as a whole.

Moreover, the construction may be applied with equal facility to the descending limb of the curve, or to exhibit the behaviour of the circuit in any cycle of magnetisation. In the line O R the descending and ascending limbs coincide; in the iron part of the circuit the ascending and descending limbs have to be drawn separately, and the process of summing the abscissas has to be applied successively to each (as in Fig. 132) in order to determine a curve which will show the effects of hysteresis in the magnetic circuit as a whole, and all the variations of magnetic flux under cyclic variations of magnetomotive force.

Again, the method may evidently be extended to magnetic circuits of a more complicated form, containing, let us say, successive pieces of different material, of lengths l_1, l_2, l_3, &c., and section s_1, s_2, s_3, &c. We must know, to begin with, the curve of B and H for each material. From these curves draw a set of curves of which the ordinates are respectively $\mathsf{B}\,s_1$, $\mathsf{B}\,s_2$, $\mathsf{B}\,s_3$, &c., and the abscissas are $\mathsf{H}_1\,l_1$, $\mathsf{H}_2\,l_2$, $\mathsf{H}_3\,l_3$, &c. The required curve of flux and magnetomotive force for the whole circuit will be found by compounding these curves; that is to say, by drawing a curve in which, for a given ordinate, the abscissa is the sum of the abscissas of the separate curves

* This construction, for finding the residual magnetism of ellipsoids, is given by J. Hopkinson, *Phil. Trans.*, 1885, p. 465.

* *Phil. Trans.*, 1886, Part I., p. 331.

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The complete curve exhibiting what happens when the complex circuit is carried through a cyclic process of magnetisation may be found in this way, provided the cyclic curves for each of the materials are determined beforehand.

§ 160. **Application to Dynamos.**—A principal use of this method is to determine the magnetomotive force, and consequently the number of ampere-turns, required to produce a stated magnetisation in a circuit made up of pieces the dimensions and magnetic qualities of which are known. The method was, in fact, invented by J. and E. Hopkinson as a means of solving practical problems in the design of a dynamo, where the magnetic circuit is made up of (1) the cores of the field magnets, (2) the yoke, (3) the pole pieces, (4) the core of the armature, and (5) the non-magnetic spaces on either side of the armature, between it and the pole pieces. This last is much the most important item in the resistance of the circuit. The magnetic circuit of a dynamo is far from perfect, and the estimation of the effective length and effective cross section of each part is subject to some uncertainty, so that the results are no more than rather roughly approximate. To pursue the application in detail would be beside our present purpose: the student should in any case refer to the original Paper.* One point, however, must be briefly mentioned, being of general interest in relation to other magnetic circuits as well as to the circuit of the dynamo.

In the dynamo circuit the flux is by no means uniform throughout; there is much leakage. The flux is greatest in the magnet limbs, which are the seat of the magnetomotive force, and in the armature it is considerably less. Its value in the armature is, however, the matter of chief interest in the practical problem. Calling F_1 the value of the flux in the armature, the fluxes F_2, F_3, &c., in other parts of the circuit may be expressed by the use of factors q_2, q_3, &c., such that $F_2 = q_2 F_1$, $F_3 = q_3 F_1$, and so on. These factors are sometimes called coefficients of leakage; in the case considered they are greater than unit. They may be found experimentally by comparing the forces ballistically by means of induction coils wound at different places in the circuit, or by measuring directly the number of stray lines of induction in the air round about the several portions. They are not strictly constant, but tend to increase when the flux approaches saturation. When they are known, we may obtain a better approximation to the true equation of the magnetic circuit by writing

$$4\pi C N = \frac{l_1 F_1}{\mu_1 s_1} + \frac{l_2 F_2}{\mu_2 s_2} + \frac{l_3 F_3}{\mu_3 s_3} + \&c.,$$

or

$$\left(4\pi C N = F_1 \frac{l_1}{\mu_1 s_1} + \frac{q_2 l_2}{\mu_2 s_2} + \frac{q_3 l_3}{\mu_3 s_3} + \&c.\right).$$

(To be continued.)

ON THE USE OF THE SILVER VOLTAMETER.

The following note on the use of the silver voltameter has been prepared by the Electrical Standards Committee of the Board of Trade:—

In the following specification the term "silver voltameter" means the arrangement of apparatus by means of which an electric current is passed through a solution of nitrate of silver in water. The silver voltameter measures the total electrical quantity which has passed during the time of the experiment, and by noting this time the time-average of the current, or if the current has been kept constant, the current itself can be deduced.

In employing the silver voltameter to measure currents of about 1 ampere the following arrangements should be adopted:—The cathode on which the silver is to be deposited should take the form of a platinum bowl not less than 10cm. in diameter, and from 4 to 5 cm. in depth.

The anode should be a plate of pure silver some 30 square cm. in area and two or three millimetres in thickness. This is supported horizontally in the liquid near the top of the solution by a platinum wire passed through holes in the plate at opposite corners. To prevent the disintegrated silver which is formed on the anode from falling on to the cathode, the anode should be wrapped round with pure filter paper, secured at the back with sealing-wax.

The liquid should consist of a neutral solution of pure silver nitrate, containing about 15 parts by weight of salt to 85 parts of water.

The resistance of the voltameter changes somewhat as the current passes. To prevent these changes having too great an effect on the current, some resistance besides that of the voltameter should be inserted in the circuit. The total metallic resistance of the circuit should not be less than 10 ohms.

Method of Making a Measurement.

The platinum bowl is washed with nitric acid and distilled water, dried by heat, and then left to cool in a desiccator. When thoroughly dry it is weighed carefully. It is nearly filled with the solution, and connected to the rest of the circuit by being placed on a clean copper support, to which a binding screw is attached. This copper support must be insulated. The anode is then immersed in the solution, so as to be well covered by it, and supported in that position; the connections to the rest of the circuit are made. Contact is made at the key noting the time of contact. The current is allowed to pass for not less than half-an-hour, and the time at which contact is broken is observed. Care must be taken that the clock used is keeping correct time during this interval.

The solution is now removed from the bowl and the deposit is washed with distilled water and left to soak for at least six hours. It is then rinsed successively with distilled water and absolute alcohol, and dried in a hot-air bath at a temperature of about 160°C. After cooling in a desiccator it is weighed again. The gain in weight gives the silver deposited.

To find the current in amperes this weight, expressed in grammes, must be divided by the number of seconds during which the current has been passed, and by ·001118. The result will be the time average of the current, if during the interval the current has varied.

In determining by this method the constant of an instrument, the current should be kept as nearly constant as possible, and the readings of the instrument taken at frequent observed intervals of time. These observations give a curve from which the reading corresponding to the mean current, time average of the current, can be found. The current, as calculated by the voltameter, corresponds to this reading.

THE SUB-TRANSFORMER SYSTEM OF LIGHTING AT CARLOW.

As briefly mentioned in our "Notes" last week, deputations from some of the principal local authorities of Ireland met at Carlow, on the 13th inst., to receive from Messrs. J. E. H. Gordon and Co., the contractors, particulars of their scheme for lighting the town by means of their "sub-transformer" system. A chief feature of the Carlow installation is the fact that power is derived from a water-wheel, erected at a distance of five miles from the town, in an unused mill on the River Barrow, a stream estimated to be capable of providing 200 H.P. so soon as the turbines, for which the necessary alterations are being made, are put down (*See* Fig. 1).

The water-wheel at present doing the work is 20ft. by 60ft. diameter, speed from 8 to 10 revolutions per minute, and this performs its duties very effectively, no hitch of any importance having yet occurred, although the light has been running for some time. There will eventually be two turbines installed (of Messrs. Carrick and Ritchie's make), and it is estimated that these will supply all the power necessary to light the five miles of straight but narrow streets of the town of Carlow, and the houses of its 6,000 inhabitants. As in most Irish towns, the proportion of large houses is small.

Messrs. Gordon have been fortunate in the selection of their field of operations, as the gas supply at Carlow was very bad, and some time ago the Town Commissioners had decided that oil

* See also a Paper by E. Hopkinson on the "General Theory of Dynamo Machines," Ref. Brit. Assoc., 1887, p. 614. Reference should also be made to Prof. S. P. Thompson's "Treatise on Dynamo-Electric Machines."

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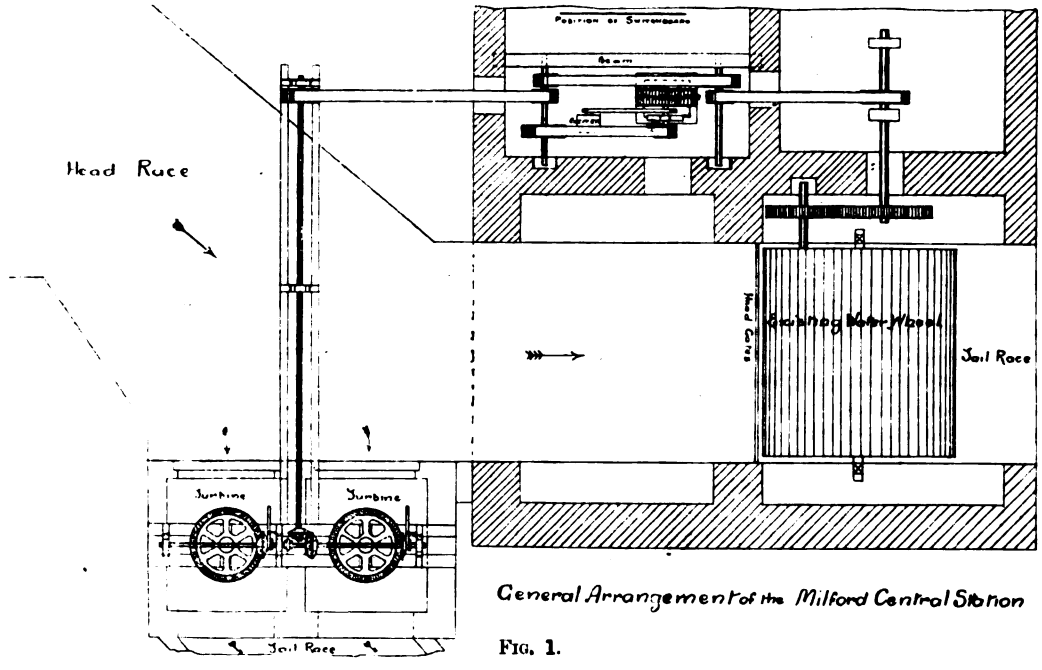
should be substituted for gas, the price of which, we understand, varied from 7s. 6d. to 5s. per 1,000 feet. The Commissioners, of whom Mr. Hammond, M.P., is the chairman, were favourably disposed towards the electric light, and accepted Messrs. Gordon's offer to light the town, granting them many facilities, such as the free use of the towing path of the Barrow for nearly five miles, for the erection of the posts for carrying the cables. Labour is cheap in the district, although the item for superintendence of the labourers must be a heavy one.



General Arrangement of the Milford Central Station

FIG. 1.

The first indication of the electric lighting is the appearance at irregular intervals of heavy posts, suspended from each of which is a Brockie-Pell arc lamp, taking eight amperes; and below the lamp about three feet, attached to the post, is a small transformer of the Gordon type. These posts are certainly not attractive, but the light is very steady, and the local press and public generally speak in terms of praise of the simplicity and effectiveness of all the arrangements.

FIG. 3.—Cable used for High-pressure Mains (7/16 insulated according to Board of Trade Rules).

A pamphlet issued by the contractors says that the "public lighting of the streets has hitherto been carried out by 100 oil lamps of 10 c.p. each, and costing the Town Commissioners £104 per year for a total light of 1,000 c.p. It is now carried out by 13 arc lamps of 1,200 c.p. each, and 40 incandescents of 16 c.p. each, giving a total light of 25,840 c.p., or 25 times the former amount; and for this the Commissioners pay £170 a year." As we understand that 8 amperes are used for the arcs, this current may, under the very best conditions, give 1,200 candles with a continuous current, at an angle of about 50

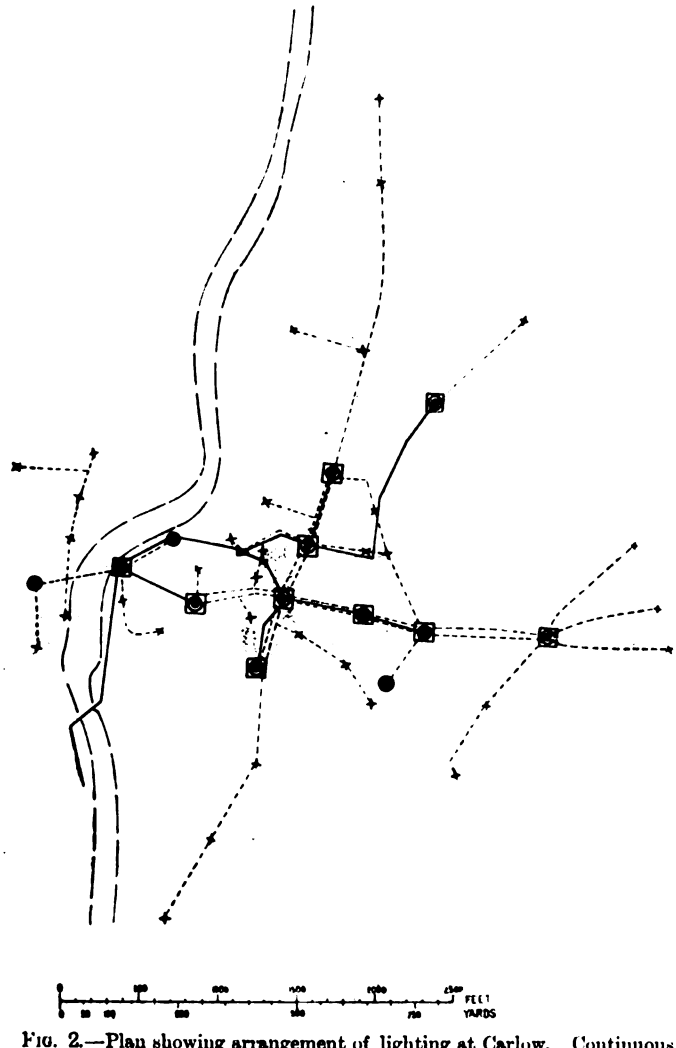


FIG. 2.—Plan showing arrangement of lighting at Carlow. Continuous lines show High-pressure Mains; dotted lines show the Low-pressure Conductors; broken lines show the river; circles represent 8 ampere Brockie-Pell Arc Lamps; stars represent 16-c.p. Glow Lamps. Squares represent Transformers: these are of 4-H P., except those at the extreme North and West which are 2-H.P.

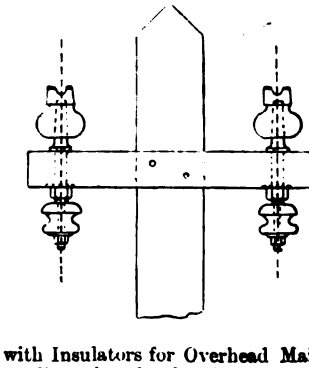


FIG. 4.—Bracket with Insulators for Overhead Mains. The upper insulators carry the suspending wire of galvanised iron; the lower ones carry the 7/16 copper mains.

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with the vertical, but we rather question whether this figure is to be relied upon as the basis of such an exact calculation as one which includes the figure of 25,840, and we doubt whether as much as 800 candles can be obtained with alternating currents.

The accompanying map (Fig. 2) shows the double system of mains and the public lamps in present use. The outlines of the streets have been omitted to avoid confusion. The main from Milford, five miles distant, enters the town, as shown on the map, from the south-west corner. The conductors are of the Fowler-Waring make. The insulation is carried out in accordance with the Board of Trade regulations, and the actual size is represented in Fig. 3. The cable is carried on steel wire bearers, and Johnson and Phillips' oil insulators are used (Fig. 4), and the average length of span is 150ft. An Elwell-Parker alternating dynamo, capable of giving 45 kilowatts, is employed, the exciter being also of the Elwell-Parker make. Goolden and Co.'s measuring instruments are used. A small switch room, marked by a triangular space on the map, is used for controlling the various circuits. The contractors, in adopting the much-talked-of sub-transformer system, have had to make a guess at the probable consumption, and have erected eight 4-H.P. transformers and two of 2-H.P. Of course, these can be re-arranged when the light is well taken up, and the high-pressure mains can be increased. We hope that customers will come on rapidly, and a fair load will be put upon these transformers, or the economy until this is done will not make a good show. A good feature in the sub station system, if indeed the transformers dotted about the town can be called stations, is that a small customer using two or three lights is *pro ratâ* as good a customer as anybody else. Where transformers are fixed in the houses a rather serious rental is demanded; supply companies indeed may make little out of it, although this rental alone has sufficed to pay a dividend on one occasion, and we are not aware that there is any statutory authority for exacting it. It is very satisfactory to learn that the work has been carried out entirely by local labour; the whole of the erection of poles, placing of machinery, wiring of houses, &c., having been done by the ordinary labourers of the district, of whom between 40 and 50 have been employed ever since the work was commenced in December last.

REVIEWS.

Leçons sur L'Electricite. Par ERIC GERARD. Deuxime Edition. (Paris: Gauthier-Villars. Liége: Léon de Thier. 1891.)

With no servile attempt to cram his readers for some cast-iron examination syllabus, and with no struggle to keep an old book up to date by stuffing it with newspaper cuttings, Prof. Eric Gerard has produced a second edition of his excellent "Lessons" within a few months of their first appearance. For some reason, which is not very clear, we have no such book in this country. A far higher standard is aimed at and maintained, and a much wider ground is covered than has been attempted by any English writer. What Deschanel did for physics, Prof. Gerard has done for the science and applications of electricity. There is no attempt to pass lightly over any subject because a mathematical treatment is required, and there is no struggle after originality. French students are to be envied in having, in two handy volumes, practically the whole of the grounding in electrical science that is necessary for an electrical engineer, and a very useful introduction to the practical side of the subject. This is essentially a modern work, and one which does not attempt to disguise the fact that a considerable portion of its contents are borrowed, with careful editing, from the works of the best writers of the day, and not from books alone, but from technical journals which appeared a remarkably short time before this second edition was published. If any fault is to be found with this book, it is that the introductory part is rather too stiff, but the title should be borne in mind, and it must be remembered that it is put forward as a complete text-book for the classes of the Montefiore Electro-Technical Institute of the University of Liége. We therefore regard from an educational point of view the juggling with C.G.S. units, the theorems about purely mathematical lines of force, the charges on infinitely thin discs and spheres, and the magnetisation of these fascinating forms. But later on there is a good resumé of the work of Hopkinson, Rowland, Barrett, and Ewing, on real magnetism, and a full account of Ewing's development of Weber's molecular theory of magnetisation.

The electrophorus is dismissed in sixteen lines, in the course of a chapter which deals with capacity, condensers, electrometers, and frictional and influence machines. Wheatstone's bridge is led up to by the mazy approach of Kirchoff's tiresome "relations." A short chapter on the energy of the electric current introduces the laws of electrolysis, and concludes the section on electricity. The phenomena of electro-magnetism are analysed into a number of definite laws, equations involving simple differential and integral calculus are given, and the laws are clearly enunciated initalics.

Using the word induction, after Faraday, to express a category of phenomena consisting in the production of a current through conductors, moved in a magnetic field, or subjected to a variable field, the author proceeds to discuss this subject in a short chapter, commencing with Lenz's law, and finishing with the experiments of Ferraris, Elihu Thomson, and Fleming. In the same systematic way, the following chapter deals with the propagation of currents, beginning with Ohm's law and Maxwell's "displacement," and concluding with a brief account of Hertz's discoveries. A practical section is devoted to standards and methods of measurement, but we are surprised to find the Clark cell, though described, meets with no special recommendation, and is followed by an illustrated account of a standard Daniell cell, as used at our Post Office. The Cardew voltmeter is in a like manner followed by a description of an ammeter, which depends on the unequal expansion of a compound metal bar, with no comment on the practical value of either instrument. After a description of batteries and accumulators, the subject of dynamos is introduced, and no space is wasted over the ancient history of Wilde and Wheatstone. This important subject is very well handled, and theory and practice are suitably proportioned. The excellent expression *entrefer* is used for "air-space," but, though it is modelled after several common French words, we do not see how it can be translated into euphonious English. We notice that in a simple diagram of the section of a commutator, the insulation at the end of the bars is omitted, though it is alluded to in the text; there are, however, very few such slips.

The second volume treats of *canalisation* and distribution, methods of calculating the size of conductors, systems of wiring and of feeders, and gives an abstract of the academical network of Herzog and Stark. The sections on meters, cut-outs, motors, traction, and transmission of power are fairly up to date, and are followed by a chapter on electric lighting which begins with sections on incandescent and arc lamps, and proceeds to deal very ably with photometers and the distribution of illumination. Several central stations are described, and the work concludes with a short chapter on electro-metallurgy.

Many of our teachers have no time to write text-books, and we often suspect some reluctance on their part to put in print the teaching which can otherwise be obtained only by attending their classes. On the other hand, it should be admitted candidly that no one man can possibly write such a comprehensive work as this without making considerable use of contemporary literature, and we regret that no one in this country has condescended to set to work with scissors and paste and a blue pencil, and to build up a complete text-book like the Venetians built their palaces; with a foundation composed of solid piles of intelligible conclusions driven through a quagmire of mathematics; with a superstructure largely composed of blocks borrowed from the works of other builders; sometimes hewn into more convenient shape, and sometimes, when more worthy, set up as they found them. The labour is not less than if the whole material had been quarried from a neighbouring mountain, and the whole design is as original as the result is excellent.

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The Electrician.

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PATENT OFFICE FEES.

After eight years' experience of the Patent Office reforms introduced by Mr. CHAMBERLAIN, the time has arrived when the question of patent fees may be again considered, and Mr. LENG is to be congratulated on having drawn from the PRESIDENT OF THE BOARD OF TRADE the most satisfactory and practical statement printed in our last issue. In one sense, there was no reduction of fees in 1883, since the total cost of a patent for the full term of fourteen years remained practically the same as before; but the excellent system, giving the option of dividing the charges into easy and gradually increasing payments, amounting to £154, had the immediate effect of encouraging a host of inventors to send in an enormous number of applications. But we have not heard that this influx brought about any real increase in the number of useful inventions which can be said, in the words of Mr. LENG, to contribute to "the advancement of our trade and manufactures, the employment of our people, and the prosperity of the country at large." There is a strong feeling in most minds that inventors should not be taxed for the mere benefit of the revenue, and Sir MICHAEL HICKS-BEACH definitely stated, on the 14th inst., that "he did not think that the country ought to look upon the Patent Office as a permanent source of income." This assurance is noteworthy, as we believe that this is the first time that a member

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of the Government has conceded the point. Patents have for so many years been regarded as monopolies, that it seemed fair that those who enjoyed the privileges created by the State should contribute handsomely towards the revenue by substantial fees. But we now realise that, to a certain extent, a man has some property in the productions of his mind and imagination, and although no stronger views about property have ever been propounded than are to be heard to-day, we are glad to find that the meddlesome socialism of the time has not attempted to sweep away the patent system. It is possible—but we will not credit them with so much logic—that these modern philosophers recognise that the patent system is one which enables a man to escape competition by paying a fee; and competition, they inform us, is not a healthy stimulant to industry, but a sordid and suicidal policy.

Reduction of the patent fees was the theme of Mr. LENG's speech, but we are not sure whether this is a matter of vital importance. He has done well in ventilating the question, now that we have had several years' experience of the present system, and he has very opportunely compared our charges with those of other nations. The numerous patents in the United States—numerous in spite of their system of examination, may seem to be connected with the small fee of £7. 5s. 10d. for 17 years, as against our £154 for 14 years; but if the former method could be worked simultaneously with our own, and each inventor had the option of selecting the rules and fees, we are inclined to doubt whether the American system would attract the majority. Experienced inventors are thoroughly alive to the fact that the value of an invention cannot possibly be judged at the early stage at which a patent is applied for. Patent Office statistics show, in the most unmistakable manner, that before nine months have elapsed a very considerable proportion of the inventions which have been provisionally protected have turned out unworthy of the £3 fee which then becomes due. In many cases the idea is novel enough, and the method of carrying it out is practicable, but the public do not want it. Very often a patentee does not discover this till several years have elapsed and hundreds of pounds have been expended. For this reason there can be no doubt that the present system of small fees for the first few years is most admirable, but the injustice of the charges for renewals or maintenance is not quite so evident. Four years is generally sufficient to enable the inventor to form an estimate of the value of his work, and it was argued in 1883 that if the patent was not then worth £10 a year it might as well be thrown open to the public. But, on the other hand, there is a great difference between £1 a year, which is paid for the first four years, and £10 a year which is demanded from the end of the fourth to the end of the seventh years; and the view of Sir M. HICKS-BEACH, that the fees charged in the interval between four years and eight years should be reduced, will be welcomed by a large number of inventors. The profits produced by minor inventions frequently fall off after a few years, instead of increasing, as is assumed by present arrangement of fees. Not unfrequently the demand is so limited that, excellent as an invention may be, and though it may go off well at first, everybody who wants it is soon provided, and after a few years the demand may have fallen off so far that the patent fees absorb an important part of the profits. It would be a great boon to the makers and inventors of those many ingenious novelties which form a considerable proportion of the hardware trade, if the patent fees could be rearranged as has been suggested. As each invention comes out and catches on, we wonder how we could have done without it, and six or eight years hence it will have dropped out, not necessarily because it has been pushed aside by an imitation, but because our wants and methods have developed.

The idea of ear-marking the revenue from the Patent Office is excellent, and, while we doubt if it is necessary "to stimulate and encourage inventors," it would tend to reconcile them to the tax if the proceeds were devoted to technical education, and this, not only in our colleges and schools, but in the formation of practical science museums and libraries, which would be useful to the inventors themselves.

The PRESIDENT OF THE BOARD OF TRADE alluded to the abridgements, and raised hopes that these would be proceeded with. Some years ago the abridgements appeared to be a matter of importance to the public and there was much grumbling about them, but no part of the Patent Office work has been more neglected and mismanaged, with the exception, perhaps, of the index. The abridgements have become almost forgotten, and many patentees have never consulted them. They were intended, we believe, for the use of those who could not examine the specifications at the libraries. But many of the provincial patent libraries are completely neglected, and the specifications are piled in heaps in some lumber room in a town-hall. If the local authorities grudge the expense, a small annual grant for binding and shelf accommodation from the Patent Office revenue would enable the provincial inventor to enjoy the same facilities for research as the Londoner. A wary patentee may, with some reason, doubt the competence of anyone but a skilled patent agent to abridge a specification with sufficient accuracy, and, as they do not give the claims, if he means to make any search at all he will prefer to go to the specifications themselves. But the index is not only a standing disgrace to our Patent Office, it is continually being changed in method and arrangement, and even in title. Two very useful volumes of the subject-matter index were produced in 1884 and 1885, and, though the classification was rather peculiar, the brief abstracts were very useful in saving time. But after this one effort, this important part of the index has not only relapsed, but has failed to give the names of the patentees, and, as if to throw more obstacles in the way of the searcher, the alphabetical index has now been removed from the new room. The Illustrated Official Journal, which first appeared in Nov., 1884, is one of the few improvements which have been provided, and we have to thank the Patent Office of the United States for the suggestion, and for showing how it ought to be done. To a large extent it supersedes the abridgements, but the claims should be given in brief to make it really useful. We do not want a popular account of the inventions, but an idea of the patent. The American Journal gives the claims only. A new building is needed, no doubt, and Sir MICHAEL HICKS-BEACH was fully justified in saying that "any more inconvenient buildings, both for the gentlemen employed and the public, he had never seen." But we should first like to see the subject-matter indices brought up to date from 1885, in the style which was then adopted and dropped, references being given to the Illustrated Journal; and proper arrangements made for Patent Office libraries throughout the country. The suggestions of the PRESIDENT OF THE BOARD OF TRADE are important, because, we take it, they are not merely the recommendation of a Government Minister but are practically concessions from the Treasury, that the revenue shall, at all events in part, be devoted to "a more efficient and economical administration of the office." If the revenue is devoted to such objects, and afterwards to the advancement of science museums and libraries, then a reduction in the charges may be considered, and we do not think that the present fees will be out of proportion to the value of a really good patent.

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OBITUARY.

WILLOUGHBY SMITH.

It is with deep regret that we announce the death of Mr. Willoughby Smith, which took place at Eastbourne, on the 16th instant, at the age of sixty-three.

The deceased gentleman entered the service of the Gutta Percha Company in the year 1848, and during the years 1849-50 he was busily engaged in the manufacture and laying of a line of copper wire, 30 miles long, and covered with gutta percha, between Dover and Calais. An interesting account of this work was given by him in his "Résumé of the Earlier Days of Telegraphy," published in the *Journal* of the Society of Telegraph Engineers and Electricians, in September, 1881. The trouble and annoyance caused by the imperfect system of making the joints in the experimental line induced Mr. Willoughby Smith to give this subject his special attention, and in the cable laid over the same course in the following year he introduced a system of joint-making which proved a great success, and, in 1855, the present system of joining and insulating the conductor. In 1852 he was engaged in the manufacture and laying of the Holyhead and Howth, Port Patrick and Donaghadee cables, and in the manufacture of the cables laid from Orford Ness to the Hague. In the same year he was also engaged in laying gutta-percha covered copper wire in a trench dug in the "six foot" of the Manchester and Liverpool line. In 1853 he had charge of the laying of ten copper wires, insulated separately with two coverings of gutta-percha, then laid longitudinally together and bound with tarred hemp, and placed in a wooden trough, in a trench made by the side of the old coach road from London to Manchester, and from Preston to Liverpool. Early in 1854, the first cable to be laid in the Mediterranean was commenced. Mr. Willoughby Smith had charge of the electrical department during its manufacture, and assisted Prof. Wheatstone with his experiments on the retardation of signals through this cable, while coiled at the works. These experiments were made for the purpose of verifying or correcting the results of similar experiments which had been made by Faraday on lengths of the core of this cable earlier in the same year. Mr. Willoughby Smith took charge of the electrical department during the laying of this cable between Spezzia and Corsica, Corsica and Sardinia, and in the following year was similarly employed in the manufacture and laying of a cable between Sardinia and Bona.

On his return from this expedition he remained at home as electrician and manager of the wire department at the Gutta Percha Works, and at once commenced to prepare for the manufacture of 2,500 miles of core for a cable which was to be laid from Ireland to Newfoundland. In 1851, after the manufacture of the single-covered copper wire laid from Dover to Calais, it was thought advisable to apply the gutta-percha in two or more thin, instead of one thick, coverings, and to insure adhesion between these separate coverings, coal-tar naphtha was employed. Time, however, showed that this solvent was very prejudicial to the durability of the gutta-percha, and in 1858 Mr. Willoughby Smith invented an insulating and adhesive compound suitable for application between each covering of the gutta-percha, instead of the coal-tar naphtha hitherto employed. This compound was soon adopted, and is in general use at the present time. In 1864 the works of Messrs. Glass, Elliot, and Co., at Greenwich, and the Gutta Percha Company were formed into "The Telegraph Construction and Maintenance Company."

In 1865 the late Sir Richard Glass, the then Managing Director of the Telegraph Construction and Maintenance Company, requested Mr. Willoughby Smith to accompany the "Great Eastern," and render assistance, if necessary, in the laying of the cable from Ireland to Newfoundland. After laying 1,200 miles, and while endeavouring to recover a fault, the cable parted. After many endeavours to recover the cable the expedition returned to refit, but ultimately it was considered that the year was too far advanced to continue such operations in mid-Atlantic. Mr. Willoughby Smith considered the electrical system employed on the occasion imperfect, inasmuch as it allowed faults, which were evidently caused on board, to pass miles astern before they were known to exist; he therefore devised a system which would keep a continuous insulation test on the whole of the cable, and allow ship and shore to converse freely through it without interfering with either the insulation or continuity tests. A very interesting account of the system is to be found in "The Working of Long Submarine Cables," a Paper read before the Society of Telegraph Engineers and Electricians, in February, 1879. Early in 1866 Mr. Willoughby Smith was appointed chief electrician to the Telegraph Construction and Maintenance Company, and in that capacity was engaged on board the "Great Eastern" during the successful laying of the cable from Ireland to Newfoundland, and the recovery and completion of the cable lost the previous year. On the return of the "Great Eastern" those who had achieved so much were much *fêted*, and the American Chamber of Commerce at Liverpool had four massive gold medals struck, and, at a public banquet given in that city, presented them to Sir James Anderson, captain of the "Great Eastern;" Sir Samuel Canning, engineer of the expedition; Willoughby Smith, electrician to the expedition; and Cyrus W. Field, chief of the originators of the enterprise.

In June, 1869, Mr. Willoughby Smith was again on board the "Great Eastern," in charge of the electrical department of the "French" Atlantic Cable. This cable was successfully laid from Brest to St. Pierre. About this time the use of india-rubber in place of gutta-percha for insulating the conductors of submarine cables was being strongly advocated on account of its comparatively low specific inductive capacity; but Mr. Willoughby Smith showed how the specific inductive capacity of gutta-percha could be reduced to an equality with, if not below, that of india-rubber. He submitted samples of core so manufactured to gentlemen eminently qualified to report upon them, and they reported that the specific inductive capacity of what was termed "Willoughby Smith's gutta-percha" was 18 per cent. lower than that of ordinary gutta-percha. This was an important discovery, as the amount represented a similar percentage of increased speed in conductors insulated with gutta-percha.

Mr. Willoughby Smith was intimately connected with the Institution of Electrical Engineers from its commencement, and he has communicated the following Papers to it:—"Underground Telegraphs," "The Effect of Light on the Electrical Qualities of Selenium," "The Working of Long Submarine Cables," "A Résumé of the Early Days of Electric Telegraphy," "Volta Electric Induction." In 1882 he was elected its president, and in January, 1883, delivered his inaugural address, which was published in the Society's *Journal*. In addition to the above, Mr. Smith has published the following Papers:—"Induction," 1882; "Volta and Magneto-Electric Induction," read before the Royal Institution, June 6th, 1884; "Induction and Conduction," 1885; and "Magnetism," 1885. In December, 1887, Mr. Willoughby Smith severed his connection with the Telegraph Construction and Maintenance Company, but he still took an interest in things electrical, as was instanced by his system for telegraphic communication without metallic contact, noticed in *The Electrician*. Only a few weeks ago, he published his book on "The Rise and Extension of Submarine Telegraphy." From the preface it appears that he contemplated writing on Subterranean Telegraphy and Electric Lighting, and it would have been interesting to have had his views on these subjects.

Mr. Willoughby Smith was a man of great force of character, possessed of strong common sense, great perseverance, rarely giving up anything until he had solved the problem in hand, and a hard and industrious worker. A firm friend and genial companion, his death will leave a blank in the lives of many friends.

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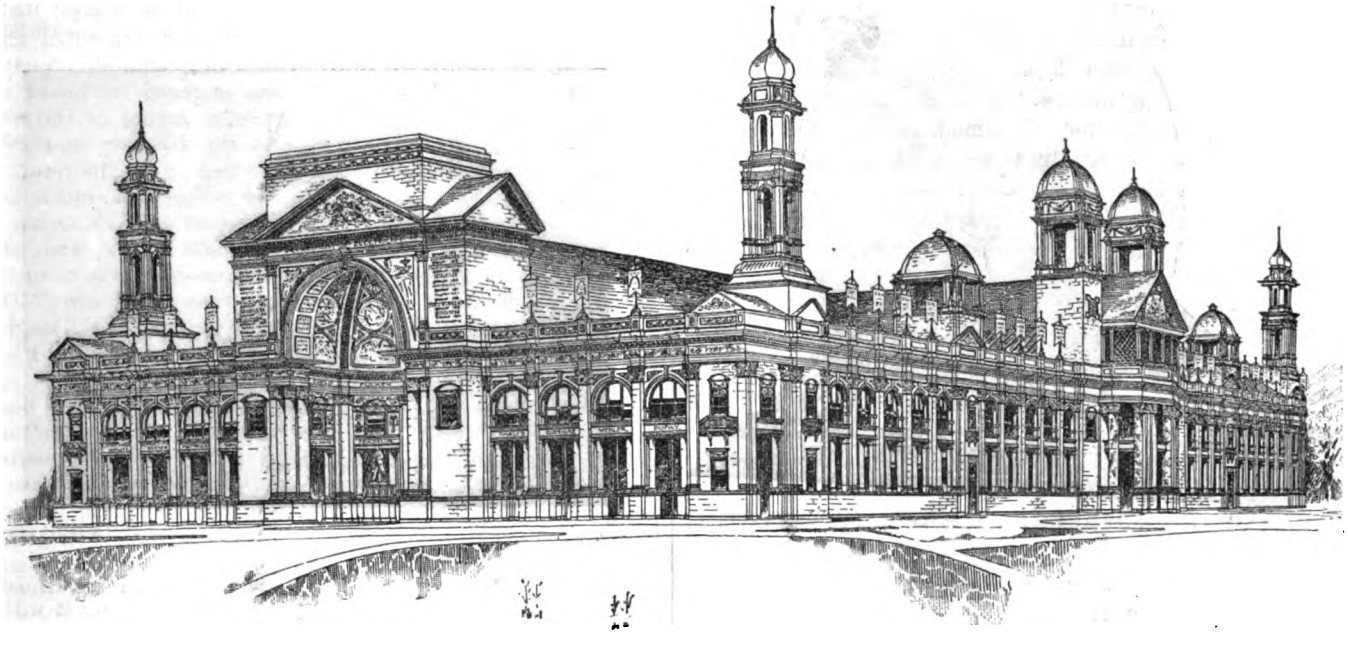
THE ELECTRICAL BUILDING AT THE CHICAGO EXHIBITION.

A number of plans for the arrangement of the grounds of the exhibition at Chicago, and several designs for the buildings, have been put forward, and several of these, after having been published, have been withdrawn. We understand that the building provided for the electrical exhibits has actually been begun, and the accompanying illustration gives a good idea of its general appearance.

The building covers a space of 700 by 350ft., or more than five and one-half acres. Like most of the other buildings, the style of architecture is highly decorative, and is, we understand, supposed to be Italian Renaissance. It is 60ft. high and ornamented with designs suggestive of the department. It is one of the handsomest of the grand central group, and will cost $650,000. There will be four entrances to the building, the main one on the south. It is being built of a material resembling granite in colour.

A statue of Franklin will rise conspicuously before the south entrance.



EXPERIMENTS WITH ALTERNATE CURRENTS OF VERY HIGH FREQUENCY, AND THEIR APPLICATION TO METHODS OF ARTIFICIAL ILLUMINATION.*

BY NIKOLA TESLA.

The phenomena which are peculiar to the changing character of the currents are greatly exalted when the rate of change is increased, hence the study of these currents is considerably facilitated by the employment of properly constructed apparatus. It was with this and other objects in view that I constructed alternate-current machines capable of giving more than two million reversals of current per minute. The investigator who desires to repeat the experiments which I describe, with an alternate current machine, capable of supplying currents of the desired frequency, and an induction coil, will do well to take the primary coil out and mount the secondary in such a manner as to be able to look through the tube upon which the secondary is wound. He will then be able to observe the streams which pass from the primary to the insulating tube, and from their intensity he will know how far he can strain the coil. The selection of the type of machine best suited for the purpose must be left to the judgment of the experimenter. There are here illustrated three distinct types of machines, which, besides others, I have used in my experiments. Fig. 1 represents the machine used in my experiments before this Institute. It caused me the least trouble in construction as well as in maintenance, and, on the whole, it has been a good experimental machine. The field magnet consists of a ring of wrought iron with 384 pole projections. The armature comprises a steel disc to which is fastened a thin, carefully welded rim of wrought iron. Upon the rim are wound several layers of fine, well annealed iron wire, which, when wound, is passed through shellac. The armature wires are wound around brass pins, wrapped with silk thread. The diameter of the armature wire in this type of machine should not be more than one-sixth of the thickness of the pole projections, else the local action will be considerable. From the behaviour of the dielectrics in these experiments we may conclude that the best insulator for these rapidly alternating currents would be the one possessing the smallest specific inductive capacity, and at the same time one capable of withstanding the greatest differences of potential; and thus two diametrically opposite ways of securing the required insulation are indicated, namely, to use either a perfect vacuum or a gas under great pressure; but the former would be preferable. Unfortunately, neither of these two ways is easily carried out in practice. To avoid misunderstanding in regard to the physiological effect of alternating currents of very high frequency, I think it necessary to state that while it is an undeniable fact that they are incomparably less dangerous than currents of low frequencies, yet it should not be thought that they are altogether harmless.

After referring to the differences which may be observed between the brush discharges obtained by means of a rapidly alternating induction coil, when compared with that obtained from a powerful static machine, Mr. Tesla described the following striking peculiarity of the brush discharge produced by very rapidly alternating currents. To observe this it is best to replace the usual terminals of the coil by two metal columns insulated with a good thickness of ebonite. It is also well to close all fissures and cracks with wax so that the brushes cannot form anywhere except at the tops of the columns. If the conditions are carefully adjusted so that the potential rises to an enormous value, one may produce two powerful brushes several inches long, nearly white at their roots, which, in the dark, bear a striking resemblance to two flames of a gas escaping under pressure (Fig. 2). But they do not only *resemble*, they *are* veritable flames, for they are hot. Certainly they are not as hot as a gas burner, *but they would be so if the frequency and the potential should be sufficiently high.* Produced with, say, 20,000 alternations per second, the heat is easily perceptible even if the potential is not excessively high. If a bulb be held over the terminal of the coil so as to inclose the brush, the air contained in the bulb is very quickly brought to a high temperature. If a glass tube be held over the brush so as to allow the draught to carry the brush upward, scorching hot air escapes at the top of the tube. Anything held within the brush is, of course, rapidly heated, and the possibility of using such heating effects for some purpose or other suggests itself. It is of no little interest to contemplate that we have a possible way of producing—by other than chemical means—a veritable flame which would give light and heat without any material being consumed, without any chemical process taking place, and to accomplish this we only

* Extracts from a lecture delivered before the American Institute of Electrical Engineers, at Columbia College, May 20, 1891.

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need to perfect methods of producing enormous frequencies and potentials. I have no doubt that if the potential could be made to alternate with sufficient rapidity and power, the brush formed at the end of a wire would lose its electrical characteristics, and would become flamelike. The flame must be due to electrostatic molecular action.

By preventing completely the exchange of the air molecules the local heating effect may be so exalted as to bring a body to incandescence. Thus, for instance, if a small button, or preferably a very thin wire or filament, be enclosed in an unexhausted globe and connected with the terminal of the coil, it may be rendered incandescent. The phenomenon is made much more interesting by the rapid spinning round in a circle of the top of the filament, thus presenting the appearance of a luminous funnel (Fig. 3), which widens when the potential is increased. When the potential is small the end of the filament may perform irregular motions, suddenly changing from one to the other, or it may describe an ellipse; but when the potential is very high it always spins in a circle; and so does, generally, a thin, straight wire attached freely to the terminal of the coil. These motions are, of course, due to the impact of the molecules and the irregularity in the distribution of the potential, owing to the roughness and dissymmetry of the wire or filament. With a perfectly symmetrical and polished wire such motions would probably not occur. That the motion is not likely to be due to other causes is evident from the fact that it is not of a definite direction, and that in a very highly exhausted globe it ceases altogether. The possibility of bringing a body to incandescence in an unexhausted globe, or even when not at all enclosed, would seem to afford a possible way of obtaining lighting effects, which by perfecting methods of producing rapidly alternating potentials might be rendered available for useful purposes.

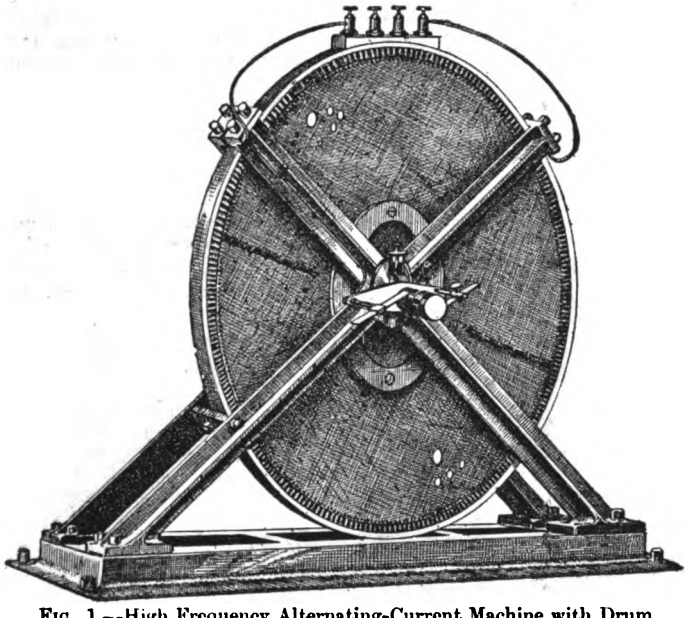

FIG. 1.—High Frequency Alternating-Current Machine with Drum Armature.

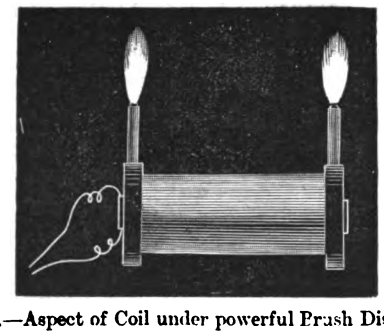

FIG. 2.—Aspect of Coil under powerful Brush Discharge.

Of all the experiments which may be performed with rapidly alternating currents, the most interesting are those which concern the production of a practical illuminant. Modern research has opened new possibilities for the production of an efficient source of light, and the attention of all has been carried in the direction indicated by able pioneers. Many have been carried away by the enthusiasm and passion to discover, but in their zeal to reach results many have been misled. Starting with the idea of producing electro-magnetic waves, they turned their attention, perhaps, too much to the study of electro-magnetic effects and neglected the study of electrostatic phenomena. Naturally, nearly every investigator availed himself of an apparatus similar to that used in earlier experiments. But in those forms of apparatus, while the electromagnetic inductive effects are enormous, the electrostatic effects are excessively small.

It has occurred to me, however, that electrostatic effects are in many ways available for the production of light. The electrostatic effects being dependent upon the potential and frequency, to produce the most powerful action it is desirable to increase both as far as practicable. It may be possible to obtain quite fair results by keeping either of these factors small, provided the other is sufficiently great; but we are limited in both directions. My experience demonstrates that we cannot go below a certain frequency, for, first, the potential then becomes so great that it is dangerous; and, secondly, the light production is less efficient.

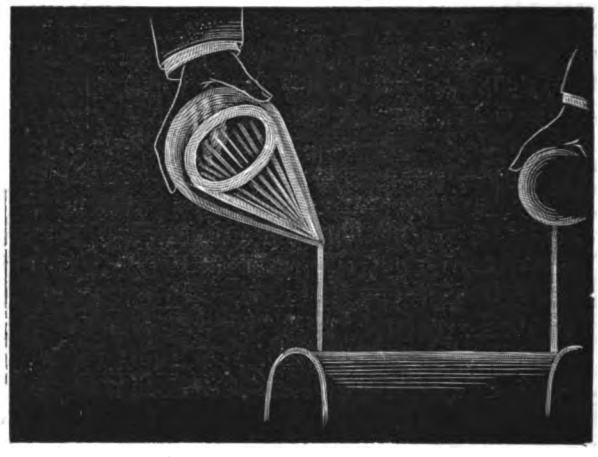

FIG. 3.—Incandescent Wire or Filament spinning in an Exhausted Globe.

I have stated above that a body enclosed in an unexhausted bulb may be intensely heated by simply connecting it with a source of rapidly alternating potential. The success of lamps of this kind would depend largely on the selection of the light-giving bodies contained within the bulb. Since, under the conditions described, refractory bodies—which are very poor conductors and capable of withstanding for a long time excessively high degrees of temperature—may be used, such illuminating devices may be rendered successful. It might be thought at first that if the bulb containing the filament or button of refractory material be perfectly well exhausted—that is, as far as it can be done by the use of the best apparatus—the heating would be much less intense, and that in perfect vacuum it could not occur at all. This is not confirmed by my experience; quite the contrary. The better the vacuum the easier the bodies are brought to incandescence. This result is interesting for many reasons.

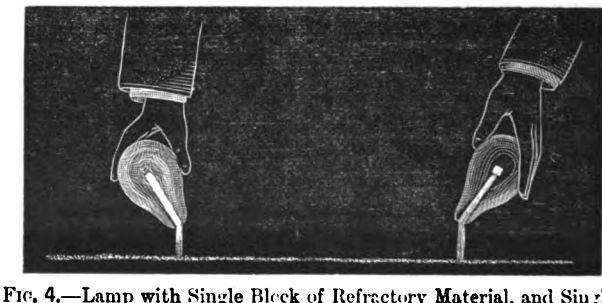

FIG. 4.—Lamp with Single Block of Refractory Material, and Single Filament Lamp.

Various forms of lamps on the above-described principle with the refractory bodies in the form of filaments have been constructed and operated by me, and investigations are being carried on in this line. There is no difficulty in reaching such high degrees of incandescence that ordinary carbon is to all appearance melted and volatilised. If the vacuum could be absolutely perfect such a lamp, although inoperative with apparatus ordinarily used, would, if operated with currents of the required character, afford an illuminant which would never be destroyed, and which would be far more efficient than an ordinary incandescent lamp. This perfection can, of course, never be reached, and a very slow destruction and gradual diminution of the size always occurs, as in incandescent lamps; but there is no possibility of a sudden and premature disabling which occurs in the latter by the breaking of the filament, especially when the incandescent bodies are in the shape of blocks. With these rapidly alternating potentials there is, however, no necessity of enclosing two blocks in a globe, but a single block, as in

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Fig. 4, may be used. The potential in this case must, of course, be higher, but it is easily obtainable, and besides it is not necessarily dangerous.

The facility with which the button or filament in such a lamp is brought to incandescence, other things being equal, depends on the size of the globe. The life of such lamps as described above depends, of course, largely on the degree of exhaustion, but to some extent also on the shape of the block of refractory mater al.

The use of alternating currents of very high frequency makes it possible to transfer, by electrostatic or electro-magnetic induction through the glass of a lamp sufficient energy to keep a filament at incandescence, and so do away with the leading-in wires. Such lamps have been proposed, but for want of proper apparatus they have not been successfully operated. Many forms of lamps on this principle, with continuous and broken filaments, have been constructed by me and experimented upon. When using a secondary enclosed within the lamp, a condenser is advantageously combined with the secondary. When the transference is effected by electrostratic induction, the potentials used are, of course, very high with frequencies obtained from a machine. For instance, with a condenser surface of 40 centimetres square, which is not impracticably large, and with glass of good quality, 1 millimetre thick, using currents alternating 20,000 times a second, the potential required is, approximately, 9,000 volts. This may seem large, but since each lamp may be included in the secondary of a transformer of very small dimensions, it would not be inconvenient, and, moreover, it would not produce fatal injury. The transformers would all be preferably in series. The regulation would offer no difficulties, as with currents of such frequencies it is very easy to maintain a constant current

The experiments which will prove most suggestive and of most interest to the investigator are probably those performed with exhausted tubes. During my investigations in this line I endeavoured to excite tubes, devoid of any electrodes, by electro-magnetic induction, making the tube the secondary of the induction device, and passing through the primary the discharges of a Leyden jar. These tubes were made of many shapes, and I was able to obtain luminous effects which I then thought were due wholly to electro-magnetic induction. But, on carefully investigating the phenomena, I found that the effects produced were more of an electrostatic

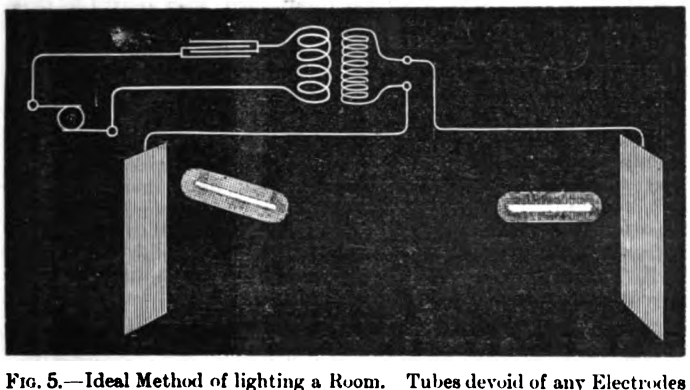

Fig. 5.—Ideal Method of lighting a Room. Tubes devoid of any Electrodes rendered brilliant in an Alternating Electrostatic Field.

nature. It may be attributed to this circumstance that this mode of exciting tubes is very wasteful; namely, the primary circuit being closed, the potential, and consequently the electrostatic inductive effect, is much diminished. When an induction coil, operated as above described, is used, there is no doubt that the tubes are excited by electrostatic induction, and that electro-magnetic induction has little, if anything, to do with the phenomena.

This is evident from many experiments. For instance, if a tube be taken in one hand, the observer being near the coil, it is brilliantly lighted, and remains so, no matter in what position it is held relatively to the observer's body. Were the action electro-magnetic, the tube could not be lighted when the observer's body is interposed between it and the coil, or at least its luminosity should be considerably diminished. When the tube is held exactly over the centre of the coil—the latter being wound in sections, and the primary placed symmetrically to the secondary—it may remain completely dark, whereas it is rendered intensely luminous by moving it slightly to the right or left from the centre of the coil. It does not light because in the middle both halves of the coil neutralise each other, and the electric potential is zero. If the action were electro-magnetic, the tube should light best in the plane through the centre of the coil, since the electro-magnetic effect there should be a maximum. When an arc is established between the terminals, the tubes and lamps in the vicinity of the coil go out, but light up again when the arc is broken, on account of the rise of potential. Yet the electro-magnetic effect should be practically the same in both cases.

By placing a tube at some distance from the coil, and nearer to one terminal—preferably at a point on the axis of the coil—one may light it by touching the remote terminal with an insulated body of some size, or with the hand, thereby raising the potential at that terminal nearer to the tube. If the tube is shifted nearer to the coil, so that it is lighted by the action of the nearer terminal, it may be made to go out by holding, on an insulated support, the end of a wire connected to the remote terminal in the vicinity of the nearer terminal, by this means counteracting the action of the latter upon the tube. These effects are evidently electrostatic. Likewise, when a tube is placed at considerable distance from the coil, the observer may, standing upon an insulated support, between the coil and tube, light the latter by approaching the hand to it; or he may even render it luminous by simply stepping between it and the coil. This would be impossible with electro-magnetic induction, for the body of the observer would act as a screen.

The effects of screening also indicate the electrostatic nature of the phenomena, and show something of the nature of electrification through the air. For instance, if a tube be placed in the direction of the axis of the coil, and an insulated metal plate be interposed, the tube will generally increase in brilliancy, or if it be too far from the coil to light, it may even be rendered luminous by interposing an insulated metal plate. The magnitude of the effects depends to some extent on the size of the plate. But if the metal plate be connected by a wire to the ground, its interposition will always make the tube go out, even if it be very near the coil.

In all the cases, then, when we excite luminosity in exhausted tubes by means of such a coil, the effect is due to the rapidly alternating electrostatic potential; and, furthermore, it must be attributed to the harmonic alternation produced directly by the machine, and not to any superimposed vibration which might be

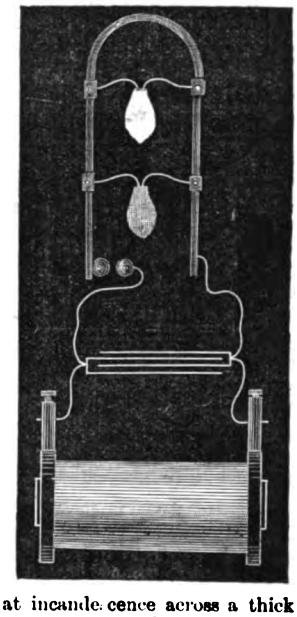

Fig. 6.—Lamp kept at incandescence across a thick Copper Bar, showing nodes.

thought to exist. Such superimposed vibrations are impossible when we work with an alternate current machine. If a spring be gradually tightened and released, it does not perform independent vibrations; for this a sudden release is necessary. So with the alternate currents from a dynamo machine; the medium is harmonically strained and released, this giving rise to only one kind of waves; a sudden contact or break, or a sudden giving way of the dielectric, as in the disruptive discharge of a Leyden jar, are essential for the production of superimposed waves.

In all the last described experiments, tubes devoid of any electrodes may be used, and there is no difficulty in producing by their means sufficient light to read by. The light effect is, however, considerably increased by the use of phosphorescent bodies, such as yttria, uranium glass, &c. A difficulty will be found when the phosphorescent material is used, for with these powerful effects it is carried gradually away, and it is preferable to use material in the form of a solid.

Instead of depending on induction at a distance to light the tube, the same may be provided with an external—and, if desired, also with an internal—condenser coating, and may then be suspended anywhere in the room from a conductor connected to one terminal of the coil, and in this manner a soft illumination may be provided.

The ideal way of lighting a hall or room would, however, be to produce such a condition in it that an illuminating device could be moved and put anywhere, and that it is lighted no matter where it is put, and without being electrically connected to anything. I

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have been able to produce such a condition by creating in the room a powerful, rapidly alternating electrostatic field. For this purpose I suspend a sheet of metal at a distance from the ceiling, on insulating cords, and connect it to one terminal of the induction coil, the other terminal being preferably connected to the ground. Or else I suspend two sheets, as illustrated in Fig. 5, each sheet being connected with one of the terminals of the coil, and their size being carefully determined. An exhausted tube may then be carried in the hand anywhere between the sheets or placed anywhere, even a certain distance beyond them; it remains always luminous.

In operating my devices I have observed curious phenomena of impedance, which are of interest. For instance, if a thick copper bar be bent, as indicated in Fig. 6, and shunted by ordinary incandescent lamps, then, by passing the discharge between the knobs, the lamps may be brought to incandescence although they are short circuited. When a large induction coil is employed it is easy to obtain nodes on the bar which are rendered evident by the different degrees of brilliancy of the lamps. When lamps with long, slender filaments are used it will be often noted that the filaments are from time to time violently vibrated. This vibration seems to be due to an electrostatic action between the filament and the glass of the bulb. In some of the above experiments it is preferable to use special lamps having a straight filament. When such a lamp is used a still more curious phenomenon than those described may be observed. The lamp may be placed across the copper bar and lighted, and by using somewhat larger capacities, or, in other words, smaller frequencies, or smaller impulsive impedances, the filament may be brought to any desired degree of incandescence. But when the impedance is increased, a point is reached when comparatively little current passes through the carbon and most of it through the rarefied gas; or, perhaps, it may be more correct to state that the current divides nearly evenly through both, in spite of the enormous difference in the resistance, and this would be true unless the gas and the filament behave differently. It is then noted that the whole bulb is brilliantly illuminated, and the ends of the leading-in wires become incandescent, and often throw off sparks in consequence of the violent bombardment; but the carbon filament remains dark. Instead of the filament a single wire extending through the whole bulb may be used, and in this case the phenomenon would seem to be still more interesting.

In presenting to you these results of my investigation on the subject under consideration I have paid only a passing notice to facts upon which I could have dwelt at length, and among many observations I have selected only those which I thought most likely to interest you. The field is wide and completely unexplored, and at every step a new truth is gleaned, a novel fact observed.

ELECTROLYSIS BY MEANS OF THE ALTERNATING CURRENT.

BY DR. GUGLIELMO MENGARINI.

(Concluded from page 303.)

Effect Produced by a High Current Density at one of the Electrodes.

If a platinum and acidulated water voltameter is traversed by an alternating current, which by means of an adjustable resistance can be kept at a constant value whilst the surface of one of the electrodes is gradually diminished, a point is reached at which the current density at the movable electrode becomes so great that large bubbles of gas are evolved, which for a moment insulate a portion of the electrode from the liquid. The metallic surface is then capable of igniting the bubbles of gas, producing small explosions and flashes of light in the liquid. With care it is possible to render the electrode incandescent along its whole length, so that it is covered with a sheet of flame from which dart flashes of bluish light with little explosions. At the same time on the first electrode, where the current density has remained constant, appears a copious evolution of gas, without comparison greater than it was at first, when the other electrode did not exhibit this phenomenon of recombination. This gas is found to be a mixture very rich in hydrogen. If it is a salt that is being decomposed, a considerable deposit of metal takes place on the second electrode, which is seen by simple inspection, without the necessity of weighing, to be very much greater than that which would have taken place under ordinary conditions. If on the electrode whose surface has been kept constant, the current density is so small that no trace of decomposition appears on it; still, as soon as the first electrode commences to be incandescent, the products of decomposition immediately appear on the second, which, in the case of solid ions, at once becomes covered with a metallic deposit, just as if it formed the negative electrode of a voltameter traversed by a direct current.

A similar result occurs if one of the electrodes, without being covered by a sheet of gas from which starts a continuous series of explosions, is surrounded by liquid in a state of strong ebullition, so that, without any luminous phenomena, the electrode gives out a feeble sound resembling the hum of a gnat. In order to carry out this experiment, it is sufficient to enclose the electrode in a porous cell immersed in the liquid. After starting the current, as soon as the density reaches a suitable value the liquid enters into ebullition.

If a third electrode of platinum is placed in the voltameter containing the two electrodes when the above experiments are being made, and a wire carried from it to one terminal of a galvanometer, the other terminal of which can be connected by means of a key to either of the two original electrodes, it is found on suddenly breaking the alternating circuit, that whilst the electrode that became incandescent is either not polarised at all, or only very feebly so, that with the larger surface shows strong polarisation, the direction of the current being the same as that from the copper pole of a volta couple.

On inserting other voltameters containing sulphate of copper, nitrate of silver, &c., in series with the first, and placing therein electrodes of such an area that decomposition does not occur when the alternating current passes through them, as soon as the above phenomenon takes place, the current remaining constant, an active electrolytic decomposition commences with deposition of copper, silver, &c., in each of the other voltameters.

Real and Apparent Energy Expended in Voltameters Traversed by Alternating Currents.

If in an alternating current circuit an acidulated water voltameter is replaced by a wire of equal resistance, the current will be increased; and if several voltameters, all of equal resistance, are constructed with electrodes of different areas, and successively inserted in the circuit, it will be found that that with the smallest electrode area will give the greatest current. This experiment was made by Kohlrausch in 1873*, and he deduced from it that it was not possible to apply Ohm's law to liquid conductors, and was forced to admit that the small quantity of gas produced by an alternation developed an appreciable electromotive force.

The investigations given above show that the phase of the difference of potential at the voltameter poles is displaced with regard to that of the current, and that polarisation, like self-induction, does not interfere with the sinoidal character of the alternating current, but that the new curve obtained by the action of either of these two causes is displaced and diminished with regard to that which would have been found if neither polarisation or self-induction had been present. Consequently, the energy really expended at any instant in a voltameter traversed with an alternating current cannot be measured by the product of the current as determined by an electro-dynamometer, and the potential difference between the voltameter poles as determined by an electrometer or a Cardew voltmeter, but a wattmeter has to be used. I had a very sensitive one with a reflecting mirror made for me by Messrs. Ganz and Co., of Budapest, which was capable of measuring very exactly the work expended in a conductor of low resistance traversed by feeble currents. The errors introduced by the instrument through the want of perfect synchronism in the currents in the two circuits, owing to self-induction in the movable coil,† were in my case absolutely negligible.

A series of 13 experiments, made with 8 equal voltameters constructed of platinum wire of an area of ·785 square centimetres each, supplies a good example of the way in which the energy really expended in the voltameters (as measured by the wattmeter) diminishes in comparison with that apparently expended (as measured by the indications of a mirror voltameter, comparable to a Cardew, and an electro-dynamometer) as the current density at the electrodes is diminished and the quantity of gas evolved is reduced. At starting, a current I of 1·798 ampere was used, which was gradually decreased, readings being simultaneously taken with the reflecting wattmeter, the reflecting voltmeter, and the electro-dynamometer. The following table gives the results of the measurements:—

I.	W.	V × A.	W/V × A.	Remarks.
1·798	40·322	45·989	0·876	Copious evolution of gas.
1·810	38·371	45·535	0·842	" " "
1·406	31·690	35·585	0·890	" " "
1·058	20·746	25·152	0·824	" " "
1·184	20·413	26·611	0·767	" " "
0·837	13·507	18·573	0·727	Evolution of gas diminishing.
0·756	10·710	15·128	0·707	Feeble evolution.
0·788	10·009	14·873	0·672	" "
0·693	9·038	13·163	0·686	" "
0·8 3	8·804	13·869	0·634	Very feeble.
0·621	6·683	10·853	0·615	"
0·503	4·628	8·290	0·558	Hardly perceptible.
0·489	4·519	7·858	0·575	" "

Mean No. of alternations 85 per sec.

* *Poyg. Ann.*, Vol. CXLVIII., p. 146. † *The Electrician* Vol. XX., p. 612.

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In this series of experiments, the voltameters having equal electrode areas, and being placed in series, the same amount of gas was produced in each. In another set of experiments, in which the electrodes were of different areas, so that, being still in series, for the different current density on the electrodes, the amounts of gas liberated were also different. Four voltameters were placed in series, and in each one of the two platinum electrodes had a surface of such size that, with a current of 2 amperes, no decomposition was apparent at it. The surfaces of the other electrode in each voltameter were as follows :—

Voltameter I. = 0·5110 sq. cent.
" II. = 0·7386 "
" III. = 1·5606 "
" IV. = 3·1056 "

The results obtained are given in the annexed Table :—

I	W.	V × A.	W/A × V.	Total active surface in sq. cent'mrs.	Number of voltameters in which gas appeared.
1·477	28·911	40·855	0·707	5·826	4 copious evolution.
1·481	28·706	40·836	0·702	5·826	4 " "
1·494	28·402	40·590	0·699	5·826	4 " "
1·510	28·292	40·796	0·693	5·826	4 " "
1·510	28·247	41·015	0·688	5·826	4 " "
1·508	28·249	40·962	0·689	5·826	4 " "
1·547	26·458	38·638	0·684	5·826	4 smaller "
1·514	23·987	35·522	0·675	5·826	4 slight "
1·610	20·455	33·117	0·617	2·810	3 feeble "
1·620	21·238	34·745	0·611	1·250	2 slight "
0·482	2·259	4·455	0·507	0·511	1 hardly perceptible.
0·487	2·303	4·484	0·513	0·511	1 " "

Mean number of alternations, 85·5 per sec.

This second series of observations is given to show that, whether the current traversing the voltameter remains practically constant or is allowed to vary between narrow limits, if the difference of potential between the poles of the voltameters is reduced, a continually increasing diminution takes place in the ratio between the real and the apparent energy absorbed in the voltameters. This alteration in the ratio can be readily explained, and is a consequence of the principles already given.

In order to facilitate the consideration of the question we will assume that the expression for the polarisation holds good for high values of the latter. Although this is not absolutely true, still to make our reasoning correct it is not only necessary to substitute for the sine function employed that which really expresses the polarisation, we have already proved that the difference of potential at any instant between the poles of a voltameter traversed by an alternating current is equal to the potential difference between the extremities of an equal resistance without induction or capacity, plus the value assumed at the instant by the electromotive force of polarisation. The curve representing the former function is sinoidal, and synchronous with that giving the current ; that representing the second is only sinoidal so long as decomposition in the voltameter does not take place ; if decomposition does occur the curve is made up of portions of sine curves connected by straight lines parallel to the axis of abscissæ.

The resultant of the two curves of potential difference and polarisation in the case when decomposition does not occur, is a new sine curve, such as V V′ V″ (Fig. 1), the resultant of O B T, P P′ P″, and in this case the phase of V V′ V″ will be found to be as far displaced as possible from that of current, which is represented by O A T. If, by increasing the current density at the electrodes or reducing the number of alternations, electrolytic decomposition is started and subsequently increases, the sine curve O B T synchronous with O A T (Fig. 1) must be combined with C M N (Fig. 2), or with C M_1 N_1, and it follows that the resultant is no longer a sine curve but a deformed curve, of which the phases approach more closely to those of the current as the straight lines M N, M_1 N_1 become longer, that is, the greater is the quantity of electrolyte decomposed.

In the limiting case when the amount of the electrolyte decomposed by an alternating current is equal to that which would have been decomposed by a continuous current giving equal quantity, the curve corresponding to C M N will coincide with the axis O T, and the phase of V V_1 V_2 will, in the result, be synchronous with that of the current. In such a limiting case, the amounts of energy really and apparently expended in the voltameter will be identical.

There is a very great similarity between an electrical transformer and a voltameter traversed by an alternating current. The resistance of the secondary circuit in the transformer, and the quantity of the electrolyte decomposed in the voltameter, exercise precisely similar effects on the current. When the external resistance in the secondary circuit of a transformer is zero, the phases of potential difference and current are very near to synchronism, and the same thing is true when there is no difference between the amounts of an electrolyte decomposed by an alternating current and by a continuous current giving equal quantity. When the external resistance of the secondary of the transformer is infinite, and electrolytic decomposition does not take place at all in the voltameter, the difference between the two phases reaches its maximum. The same thing may also be said for the difference between the energies really and apparently consumed in the voltameter.

Experiments with Interrupted Direct Currents.

Platinum is the only metal which is not acted upon when it is used as an electrode for the electrolysis of water by means of a direct current ; when other metals are used the positive electrode is seen to become covered with a black or brown film which, after having reached a certain thickness, finally stops the internal development of hydrogen at the negative poles. The layer of brown powder formed round the positive electrode is then seen to dissolve, and then the electrode itself is vigorously attacked.* The positive electrode may thus be completely dissolved, but this, of course, requires a considerable space of time. Gold is not an exception to this rule, as it becomes covered with a dark red powder at the positive pole. Platinum, however, is not acted upon, but both poles remain quite bright, even when the duration of the current is considerable.

On the other hand, in electrolysis with an alternating current, the film of brown powder quickly appears at both platinum electrodes when feeble or strong currents are used. Consequently, the properties of platinum, in conjunction with alternating and continuous currents, are very different. The difference, however, disappears

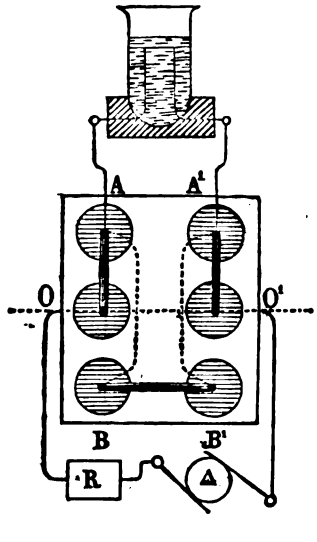

Fig. 4.

when, instead of direct continuous currents, we use direct currents made to alternate by means of a commutator, or (which is more important) when direct intermittent currents are used, and the voltameter is so arranged that it is short circuited at the conclusion of any current impulse and remains so until the commencement of the next.

In order to study this phenomenon, I made use of the apparatus represented in Fig. 4. An oscillating interruptor, consisting of six mercury cups, was constructed, its movable part being a plate of ebonite, above which were placed three pieces of copper wire terminating at the six points A A′, B B′, O O′ ; when the ebonite plate oscillates about the axis O O′, contact is made between the wires and the cups, either at A A′, or at B B′. The wires from an acidulated water voltameter were connected to the mercury cups under A A′. The leads from a direct-current dynamo Δ, after passing through a resistance, R, pass to the cups under O O′, so that for half an oscillation of the interruptor the current passes through the voltameter, which, during the other half oscillation, is short-circuited by way of the wires represented by dotted lines passing from the cups A A′ to B B′, which two latter are joined for half an oscillation by the thick wire B B′. This interruptor was worked by a small motor, and a registering mechanism was attached to count the number of times that the current passed through the voltameter. About 70 interruptions per minute were produced.

After 20,296 oscillations with a current of 0·171 amperes, the negative electrode was covered with a blackish film, the positive being quite bright. Since the blackening always takes place at the negative pole, it must be due to the action of the hydrogen. A difference of current density at the two electrodes has no effect on

* *Planté*, p. 10.

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this blackening. The phenomena are obtained either with electrodes of equal surface or not, whether they are very small or not, and when the current density is below ·01 ampere per square centimetre.

No such result as we have above described occurs if the voltameter is not short circuited when the current through it is cut off. On using the apparatus shown diagrammatically in Fig. 4, after removing the wire between B and B′, both the platinum electrodes were found to be perfectly bright after 60,720 interruptions with a current of ·161 ampere. When the wire B B′ was replaced, 4,420 oscillations were sufficient to start the blackening of the surface.

This experiment makes it clear that, in order to reproduce this characteristic of platinum electrodes in electrolysing water by an alternating current, it is not necessary to make use of a direct current caused to alternate by means of a commutator, but it is sufficient if a polarisation, constant in sign but rapidly pulsating in magnitude, occurs at the negative electrode.

Rectification of Alternating Currents by Means of Electrolysis.

It may be easily shown that a voltameter with gold or platinum electrodes becomes polarised by the passage of an alternating current. If the electrodes have different areas the larger one behaves like the electrode surrounded by hydrogen in a gas battery. The polarisation or secondary current is of few moments. But if the voltameter receives a rapid series of charges with an alternating current, the discharges are all in the same direction, and, consequently, a true rectification of an alternating current is effected.

In order to show this I made use of a rotating contact-breaker (Fig. 5). Two wooden cylinders, A and D, were mounted on the

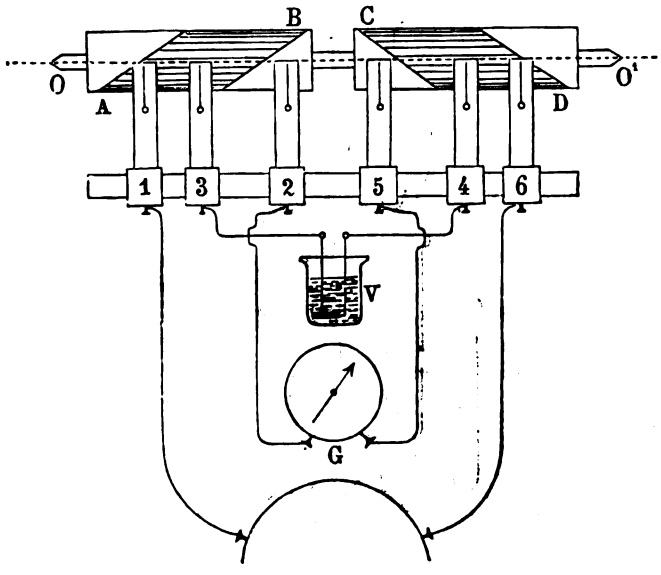

Fig. 5.

same spindle, and each was provided with a brass tube, A B C D, cut off helically at the extremities. The spindle, O O′, was rapidly rotated by means of a series of spur wheels and pinions. Six copper wire brushes, capable of sliding on a wooden rod, rubbed on the surfaces of the cylinders. During a rotation the brushes, 1, 2, 5 and 6, were in contact with the metal surfaces for a greater or smaller period of time, according to their position on the wooden rod; the brushes 3 and 4 were in permanent contact with the metal surfaces. Three distinct circuits were connected to these three pairs of brushes. An acidulated water voltameter was connected to 3 and 4, a reflecting galvanometer with its shunt to 2 and 5, and leads to the poles of an alternating current transformer to 1 and 6. With this arrangement, on rotating the spindle, O O′, at first an alternating current of short duration was sent through the voltameter, and then the current due to the polarisation set up was sent through the galvanometer, and the needle was deflected, but returned immediately to zero. If, however, the rotation was made sufficiently rapid it was found possible to find a speed at which the needle was permanently deflected.

Several different pairs of metals were examined, but the best results obtained were from the combination gold-platinum. The gold electrode had a surface of 300 square millimetres, and the platinum electrode 900 square millimetres. On rotating the communicator at a velocity of 5 to 10 revolutions per second, and placing the first and second pairs of brushes so that the voltameter was connected to the galvanometer for three-quarters of a revolution, and for less than one-quarter to the transformer, a direct current was obtained varying from 14·10 milliamperes to 47·00 milliamperes. The charging current could be varied from 0·5 to 3 amperes without obtaining any better result.

Conclusions.

(1.) In a voltameter traversed by an alternating current polarisation is set, varying periodically both in intensity and sign, in consequence of which the phase of the current is displaced behind that of the potential difference of the voltameter poles.

(2.) Electrolytic decomposition by means of an alternating current cannot take place unless the maximum value which can be reached by the polarisation during an alternation is equal to, or greater than, a certain definite limiting value depending on the natures of the electrolyte and the electrodes, and on the current density at each electrode.

In this case, during each alternation from the moment when the polarisation reaches this limit, electrolytic decomposition will occur, and will continue until the end of the alternation, that is, until the curve representing the current passes through the value zero. Thus, during each alternation there are two distinct periods: in the first, which lasts from the commencement of the current phase until the polarisation reaches the limiting value, decomposition will not take place; in the second, which occupies the remaining portion of the alternation, electrolysis proceeds regularly, and the quantity of the electrolyte decomposed will be proportional to the quantity of electricity which has passed through the voltameter in this interval. During successive alternations the same phenomena are repeated, so that at the end of any time it will be found that during a fraction only thereof has electrolysis been able to take place.

(3.) If we have two currents, one direct and the other alternating according to a sine curve, such that each conveys the same quantity of electricity through a voltameter in a given time, the quantity of the electrolyte decomposed by the former will be to that decomposed by the latter as the area corresponding to the duration of an alternation reckoned between two consecutive passages of the current through the zero value is to the area comprised in the interval of time during which electrolysis has been able to take place.

(4.) Diminishing the current density on one of the electrodes at which the products of electrolytic decomposition appear has the effect of diminishing the polarisation at this electrode. Consequently a point can be reached at which the polarisation during an alternation cannot reach the limiting value at which the products of decomposition can commence to appear; electrolysis will then cease to take place at this electrode.

If no electrolytic decomposition is seen to take place at one electrode of a voltameter traversed by an alternating current, increasing the current density will increase the polarisation so that it is possible to reach the above-mentioned limit, and then electrolysis will become visible at this electrode.

(5.) On increasing the rapidity of alternation of an alternating current, the strength and current density remaining constant, the polarisation on the same electrode in the same voltameter will continually decrease, so as to render it possible to bring it below the limit necessary for the products of electrolysis to be able to appear.

On the other hand, if, with a certain number of alternations, electrolysis is not obtained, diminishing the number of alternations will increase the polarisation so as to make it possible to reach the limit necessary for the products of decomposition to appear.

(6.) The energy consumed in a voltameter traversed by an alternating current is less than the product of the square root of the mean square of the current and the square root of the mean square of the potential difference at the voltameter poles. A voltameter traversed by an alternating current behaves like a metallic conductor possessing self-induction.

(7.) The ratio between the real and the apparent energy consumed in a voltameter traversed by an alternating current is nearer and nearer to one, the greater is the quantity of the electrolyte decomposed, the current density and number of alternations remaining constant.

If the same quantity of the electrolyte is decomposed by an alternating current as by a continuous current of equal quantity, the difference between the energies really and apparently consumed in a voltameter must be zero. The phases of the curves representing current and difference of potential at the voltameter poles would then be synchronous.

(8.) In a voltameter containing acidulated water, or a saline solution, the quantity of the electrolyte decomposed at an electrode by an alternating current (the current density at the electrode and the number of alternations remaining constant), increases if an obvious re-combination of the gases at the other electrode takes place. Owing to this re-combination, a direct current is superimposed on the alternating current, modifying its character.

In this way, with alternating currents, metallic deposits of copper, silver, nickel, &c., quite equal to those produced by direct currents can be obtained.

(9.) Alternating currents can effect the decomposition of fused salts, and this decomposition is subject to the current density law.

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(10.) After a voltameter with gold or platinum electrodes has been traversed by an alternating current, a polarisation that will last some little time will be produced.

In general the electrode with the greater surface will act as the hydrogen electrode in a gas battery. The smaller electrode often presents a more intense polarisation, but of shorter duration.

(11.) By taking advantage of this polarisation, voltameters through which alternating currents pass can be used as a means of rectifying the same, transforming them into a series of direct currents of short duration, succeeding each other at brief intervals.

(12.) During electrolysis by alternating currents the electrodes are vigorously attacked and quickly destroyed.

Even platinum, gold, and iridium become covered with a powder, which increases, until it finally completely destroys the electrode.

THE EDISON ELECTRIC LIGHT COMPANY v. THE UNITED STATES ELECTRIC LIGHTING COMPANY.

DECISION OF JUDGE WALLACE IN THE U.S. CIRCUIT COURT, JULY 14, 1891.

We received yesterday from our New York contemporary, the *Electrical World*, of New York, the following full report of the judgment given in the above action. A Reuter's telegram of yesterday's date states that a suspension of the injunction has been granted for fifteen days pending an appeal :—

Two claims of letters patent, No. 223,898, granted Thomas A. Edison, January 27, 1880, for an improvement in electric lamps are in controversy in this suit. These are claims 1 and 2. It is not asserted for plaintiff that the defendant infringes the other claims of the patent, consequently they will require no attention further than to see whether their terms may assist in defining the meaning of the claims in litigation.

The plaintiff contends that these claims are for fundamental inventions of great merit, and are entitled to a construction by which every incandescent lamp for electric lighting, consisting essentially of a filamentary carbon burner, hermetically sealed in a glass vacuum chamber, is within their terms. The defendant contends that unless the claims are limited to narrow inventions, not employed by the defendant, they are invalid for want of patentable novelty. The questions of the validity and scope of the patent have been adjusted in the Courts of England and Germany with a diversity of opinion by the judges who have considered them. The specification is a perplexing one. The difficulty lies in its shadowy demarcation of the line between the essential and non-essential feature of the invention described. It catalogues a number of discoveries which Mr. Edison had made ; it sets forth some of the essential features of the lamp, and then it leaves to be found by inference from generalities what the elements are of the combinations included in the extremely elastic terms of the two important claims.

Nevertheless, when a sufficient knowledge of the prior state of the art to which it relates has been acquired, the new departures from the old devices which it describes, and which, presumably, the inventor proposed to incorporate into the claims of his patent, are reasonably apparent. The specification states that the object of the invention is "to produce electric lamps giving light by incandescence, which lamps shall have a high resistance so as to allow of practical subdivision of the electric current into numerous small units and their conversion into luminous centres." By practical subdivision is meant a distribution and division of the current and its conversion into lights comparable with those of ordinary gas jets, on a scale and under conditions of convenience and economy adequate to a system of illumination for domestic purposes in villages and cities analogous to that of gas. Prior to 1879 there was no method known by which this could be done practicably. The problem involved the perfection of devices for the proper distribution and regulation of the current, as well as those for translating it into the light. No reference to the pre-existing devices for generating electricity, conducting it to the translating devices, or regulating its pressure and quantity, is necessary except to state that the principles governing the relation of the resistance of translating devices to the character of the circuit in which they are arranged, whether in series or in multiple arc, were well known to electricians, and had been applied in various forms of electrical apparatus. There were two well-known devices for converting the current into light—the arc lamp and the incandescent lamp. In the former the current is forced to leap an air gap separating two conductors, usually of carbon, and in overcoming the resistance of the air space heats the adjacent surfaces of the conductors and produces a light of great intensity. In the latter light is produced by the incandescence of an electrical conductor, a conducting strip of burner, placed in a continuous circuit through which the current passes and which develops heat by its resistance to the flow. The arc lamp was suitable for use in streets, open spaces and large halls, but its light was too concentrated and powerful for the illumination of dwellings or of rooms of small dimensions. It was the generally accepted opinion of electricians that the hope of progress in the subdivision of the electric light was to be found in modifying the features of the arc lamp. The reason for this conclusion need not be mentioned ; it suffices to say that Mr. Lane-Fox in England, and Mr. Edison in this country, seem to have been the only notable dissidents, and each of them had expressed the conclusion that subdivision might be accomplished by the incandescent lamp when provided with a conductor of high resistance and small radiating surface arranged in system of multiple arc. Lane-Fox had set forth the advantages of such a lamp in three patents granted to him in England, and two in October, 1878, and one in March, 1879, and in a letter to the London *Times*, published in December, 1878 ; and Mr. Edison had done so in a patent granted to him in France, May 28, 1879, for improvements in electric lighting.

By arrangement in multiple arc no greater electromotive force is required for a large number of translating devices than for a single one, and the amount of current can be graduated to the number employed ; consequently, a lamp with a conductor of high resistance can be utilised as efficiently as one with a conductor of low resistance. Higher resistance in the conductor permits the use of a weaker current, and, consequently, of smaller and less expensive main conductors. With a small surface of conductor less energy is required to produce a candle power, and the small incandescent mass will radiate a moderate light, like the domestic lamp. Electricians knew how to make conductors of high resistance, and how to make them with a small radiating surface. They knew that with the materials of the same specific resistance the total resistance of the conductor could be varied by varying its length and cross section. They knew what materials were preferable and what processes of treatment to make conductors of high or low resistance.

If they had only known how to construct a lamp in which the conductor would have adequate mechanical strength and durability for practical commercial use, while having the small radiating surface and high resistance desirable, there would have been nothing wanting, and electric lighting by incandescence would soon have been an accomplished fact. Although Lane-Fox and Edison had contributed to the state of the art the recognition of the principle that the conductor must have high resistance and small radiating surface, and each of them had embodied the principle in lamps, for which they had severally obtained patents, neither of them had invented a lamp which satisfactorily embodied all the conditions of success because a burner of the necessary material, form, and complementary adjuncts was yet to be devised. As to material, experiments had been tried with platinum, iridium, and alloys of these metals, and with carbon of various kinds. It was known that platinum, being a poor conductor, could be readily brought to incandescence by the electric current, but to do so it was necessary to raise it to a temperature very near the fusing point, and a minute increase would melt it. On the other hand, carbon was known to possess at an equal temperature much greater power of radiation than platinum, but the difficulty was that it would combine with oxygen at high temperature and rapidly disintegrate. It could only be used, therefore, in a vacuum which was practically unattainable. From the earliest lamp (disregarding the Geisler tube, because it has no burner in the true sense), patented in England by King in 1849, to the latest examples, like those of Lane-Fox or Edison's platinum lamp, patented in 1878-9, the history of the art shows a variety of experiments to perfect a lamp in which a carbon burner or a platinum burner would have sufficiently long life for practical requirements. The result of these experiments may be succinctly shown by quoting two well-known electricians. Mr. Schwendler, in an article published in 1879 in the *Telegraphic Journal*, said : "Unless we shall be fortunate enough to discover a conductor of electricity with a much higher melting point than platinum, and the specific weight and specific heat of which conductor is also much lower than for platinum, and which at the same time does not combine at high temperatures with oxygen, we can scarcely expect that the principle of incandescence will be made use of for practical illumination." Mr. Sawyer, in a patent to Sawyer and Man, granted in June, 1878, said : "At the present day it is not new to produce a light by causing the electric current to heat a carbon conductor to incandescence in a vacuum, or in nitrogen, or in other gas ; but no lamp has yet been devised which would be practically operative, and for these reasons : First, the methods which have been adopted for charging the lamp with the artificial atmosphere, such as a displacement of mercury, water, or air by the gas, or the combustion of phosphorus in the lamp, are imperfect. A perfect vacuum is unattainable. Some oxygen or other element or compound remains in the lamp, and slow consumption or disintegration takes place, for the remaining gas or vapour other than hydrogen or nitroge attacks the carbon, which, in turn, is decomposed, with a result of depositing some carbon upon the globe and setting free the oxygen to attack fresh carbon. Second, it has been found practically impossible under the varying degrees of heat and pressure to maintain perfect joints, and the result is that expansion of the artificial atmosphere by the heat from the luminous conductor expels a portion of the same, and the contraction of the atmosphere, upon cooling, causes a portion of the external air to penetrate the globe, thus supplying oxygen, which at the least lighting feeds upon the carbon. Third, the unequal expansion of the carbon and its holders has resulted in fractures of the former, so that, however perfect the atmosphere in the globe, the lamp has never been permanent."

The most advanced type of carbon burner lamps in 1875 were the lamps of Lodyguine or of Konn, and until the spring of 1879 lamps like those of the Sawyer and Man patent or the patents of Mr. Farmer. It was thought to be the merit of Lodyguine's lamp that it obviated the difficulty of the short life of the burner by using two burners, rods of diminished section at the luminous focus, on a glass receiver. hermetically sealed and filled with nitrogen, electrically arranged so that the current would be passed to the second carbon when the first had been consumed. Konn provided his lamp with five carbon burners, in the form of rods or pencils, and devices for bringing them successively into circuit. In the lamp of Sawyer and Man the carbon burner was a rod or pencil maintained in a globe, and its stopper (both of glass) was held together by a clamping device. In the lamp of the patents granted to Mr. Farmer in March, 1879, the burner was a carbon rod or pencil, enclosed in a globe filled with hydrogen or other analogous gas, and the globe was closed by a rubber stopper. In none of the lamps, except the

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one described in Mr. Edison's prior French and English patents of 1879, had any attempt been made to make the vacuum chamber wholly of glass, with the parts sealed together by fusion, or to seal the conducting wires leading to the burner, through the glass by fusion of the glass. The impracticability of maintaining a carbon burner under such conditions that it would be sufficiently durable, has, apparently, so impressed those who were studying lighting by incandescence that, as late as in the early part of 1879, both Lane-Fox and Edison were trying to perfect a burner of other material. Edison's burner in his French patent of May 28, 1879, was of platinum wire coiled upon a bobbin, composed of an infusible oxide, and Lane-Fox's burner in his patent, of May 14, 1879, was of platinum-iridium alloy, or of spiral strips of metal, surrounding a tube of glass, fire-clay, steatite, or lime, with the surface of the metal strips covered with asbestos or some vitreous material.

This cursory view of the prior state of the art is sufficient for an intelligent reading of the specification. The specification describes the general nature of the invention as follows:—

"The invention consists in a light-giving body of carbon wire or sheets coiled or arranged in such a manner as to offer great resistance to the passage of the electric current, and at the same time present but a slight surface from which radiation can take place.

"The invention further consists in placing such burner of great resistance in a nearly perfect vacuum, to prevent oxidation and injury to the conductor by the atmosphere. The current is conducted into the vacuum bulb through platina wires sealed into the glass.

"The invention further consists in the method of manufacturing carbon conductors of high resistance, so as to be suitable for giving light by incandescence, and in the manner of securing perfect contact between the metallic conductors or leading wires and the carbon conductors."

The specification then recites that previously light by incandescence has been obtained from rods of carbon of one to four ohms resistance, placed in closed vessels in which the atmospheric air had been replaced by gases that did not combine chemically with the carbon; that the vessels holding the burner had been composed of glass cemented to a metal base; that the connection between the leading wires and the carbon had been obtained by clamping the carbon to the metal; that the leading wires have always been large, so that their resistance should be many times less than the burner, and, generally, the attempts of previous persons had been to reduce the resistance of a carbon rod. It then points out the disadvantages of such a lamp, stating that it could not be worked in great numbers in multiple arc without the employment of main conductors of enormous dimensions; that, owing to the low resistance, the leading wires have to be of large dimensions and good conductors, and a glass globe cannot be kept tight at the place where the wires pass in, and are cemented, and consequently the carbon is consumed, because there must be almost a perfect vacuum to render it stable, especially when it is small in mass and high in electrical resistance; and that the use of gas in the receiver at the atmospheric pressure serves to destroy the carbon by attrition.

The specification then states, in substance, that the patentee proposes a new departure; that he has discovered that even a cotton thread, properly carbonised and placed in a sealed glass bulb exhausted to one-millionth of an atmosphere, offers from 100 to 500 ohms resistance to the passage of the current, and that it is absolutely stable at very high temperatures; that if the thread be coiled as a spiral and carbonised, or if a fibrous vegetable which will leave a carbon resistance after heating in a closed chamber be so coiled, as much as 2,000 ohms resistance may be obtained without presenting a radiating surface greater than three-sixteenths of an inch; that if such fibrous material be rubbed with a plastic compound of lampblack and tar its resistance may be made high or low, according to the amount of lampblack placed upon it; that carbon filaments may be made by a combination of tar and lampblack, the latter being previously ignited in a closed crucible for several hours, and afterwards moistened and kneaded until it assumes the consistency of thick putty; that small pieces of this material may be rolled out in the form of wire as small as seven one-thousandths of an inch in diameter and over a foot in length, and the same may be coated with a non-conducting, non-carbonising substance and wound on a bobbin, or as a spiral, and the tar carbonised in a closed chamber by subjecting it to high heat, the spiral after carbonisation retaining its form; that he has carbonised and used cotton and linen thread, and splints, papers, coned in various ways, also lampblack, plumbago, and carbon in various forms, mixed with tar and kneaded so that the same may be rolled out into wires of various lengths and diameters; that each wire should be uniform in size throughout; and all those forms are fragile, and cannot be clamped to the leading-in wires with sufficient force to ensure good contact and prevent heating; that if platinum wires are used, and the plastic lampblack and tar material be moulded around it in the act of carbonisation, there is an intimate union by combination and by pressure between the carbon and platinum, and nearly perfect contact is obtained without the necessity of clamps; that the burner and leading wires should be connected to the carbon ready to be placed in the vacuum bulb, and when fibrous material is used the plastic lampblack and tar should be used to secure it to the platina before carbonising.

The specification proceeds as follows:—

"By using the carbon wire of such high resistance I am enabled to use fine platinum wires for leading wires, as they will have a small resistance compared to the burner, and hence will not heat and crack the sealed vacuum bulb. Platina can only be used, as its expansion is nearly the same as that of glass.

"By using a considerable length of carbon wire and coiling it, the exterior, which is only a small portion of its entire surface, will form the principal radiating surface; hence I am able to raise the specific heat of the whole of the carbon, and thus prevent the rapid reception and disappearance of the light, which on a plain wire is prejudicial, as it shows the least unsteadiness of the current by the flickering of the light, and if the current is steady the defect does not show."

The specification then gives directions for carbonising the carbon thread in a manner to prevent its distortion, for blowing a glass bulb over it after it is formed, for exhausting the glass bulb, and for hermetically sealing the bulb when a high vacuum has been reached.

The claims are as follows:—

"1. An electric lamp for giving light by incandescence, consisting of a filament of carbon of high resistance, made as described, and secured to metallic wires as set forth.

"2. The combination of carbon filaments with a receiver made entirely of glass and conductors passing through the glass, and from which receiver the air is exhausted, for the purpose set forth.

"3. A carbon filament or strip coiled and connected to electric conductors so that only a portion of the surface of such carbon conductors shall be exposed for radiating light, as set forth.

"4. The method herein described of securing the platina contact-wires to the carbon filament, and carbonising of the whole in a closed chamber, substantially as set forth."

The specification is addressed to those who were skilled in the art to which it relates; who appreciated the advantages of arranging incandescent lamps in a system of multiple arc, and of providing the lamp with a burner of high resistance and small radiating surface; who knew how high resistance, both specific and total, is imparted to a conductor; who knew that the rods, pencils, or other forms of carbon burners previously used had not been designed to embody the principle of high resistance; who knew how desirable it was to maintain the burner in a perfect vacuum, or in gases that would exclude the oxygen; who knew what had been attempted and had proved impracticable in that behalf; who knew that such materials as are mentioned in the specification (even the tar-putty compound seems to have been used in one process) would compose a carbon of high resistance when subjected to a proper process of carbonisation; and who knew how to practise proper processes for the carbonisation of such materials.

Read by those having this knowledge, the radically new discovery disclosed by the specification is that a carbon filament as attenuated before carbonisation as a linen or cotton thread, or a wire seven one-thousandths of an inch in diameter, and still more attenuated after carbonisation, can be made which will have extremely high resistance and be absolutely stable when maintained in a practically perfect vacuum. It informs them of everything necessary to utilise this discovery and incorporate it in a practical lamp. It describes, with the assistance of the recital in the second claim, as the vacuum in which the burner is to be maintained, a bulb made wholly of glass, exhausted of air, sealed at all points by the fusion of the glass, and in which platinum leading wires are sealed by the fusion of the glass. It describes the materials of which the burner is to be made, and instructs them that the materials are to be shaped into their ultimate form before carbonisation. It describes the use of platinum for leading wires, and a method of securing the leading wires and filaments, intended to dispense with clamping, which consists in moulding tar-putty about the joints, and carbonising the whole in a closed chamber. Besides stating that the resistance of the burner will be greatly increased, and the radiating surface still be kept within moderate limits, by coiling it in the form of a spiral, the specification states that, by increasing the lengths of the filament coiled, the exterior only will be the principal radiating surface, and greater steadiness of illumination will be promoted.

The first claim must be read with several limitations. The filament is to be made of carbon of high resistance; that is, as the experts agree, of high specific resistance. The filament is to be made as described; that is, the materials are to be of some of the kinds described, and are to be shaped in filamentary form, and then carbonised. The filament is to be secured to metallic wires according to the method of the patent, because the claim implies the elements of a globe and metallic conductor arranged in circuit with the burner, otherwise the combination would not be operative, and it would have been needless to specify the securing of the metallic wires to the filament unless it was intended to insert into the claim the specific method of doing so emphasised in the specification.

The defendant does not infringe this claim, if for no other reason, because the leading wires in its lamps are not secured to the filament according to the method of the patent, that is, by cement carbonised *in situ*, by clamps such as the specification condemns.

The second claim is broad enough in its phraseology to secure the real invention described in the specification, and can be read consistently with its language so as to impart into it every essential limitation.

It was a remarkable discovery that an attenuated thread of carbon would possess all the long-sought qualities of a practical burner when maintained in a perfect vacuum. The extreme fragility of such a structure was calculated to discourage experimentation with it, and it does not detract in the least from the originality of the conception that previous patents had suggested that thin plates, or pencils, or small bridges could be used. The futility of hoping to maintain a burner in vacuo with any permanency had discouraged prior inventors, but Mr. Edison is entitled to the credit of obviating the mechanical difficulties which disheartened them, but what he did in this respect was a matter of only secondary merit, and was no longer new in the art because he had already disclosed it in his French and English patents. What he actually accomplished was to unite the characteristics of high resistance, small radiating surface, and durability in a carbon conductor by making it in a form of extreme tenuity, out of any such materials as are mentioned in the specification, carbonising it, and arranging it, as he had previously arranged his platinum burner, in an exhausted bulb made wholly of glass and sealed at all points, including those where the leading wires entered, by the fusion of the glass. He was the first to make a carbon of materials

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and by a process which was especially designed to impart high specific resistance to it; the first to make a carbon in the special form for the special purpose of imparting to it high total resistance; and the first to combine such a burner with the necessary adjuncts of lamp construction to prevent its disintegration and give it sufficiently long life. By doing those things he made a lamp which was practically operative and successful, the embryo of the best lamps now in commercial use, and but for which the subdivision of the electric light by incandescence would still be nothing but the *ignis fatuus* which it was proclaimed to be in 1879 by some of the learned experts who are now witnesses to belittle his achievement and show that it did not rise to the dignity of an invention.

The coiled form of the burner is only an alternative feature, and is not a constituent of the second claim. It is the subject of the third claim. Nor is the bent form or any form other than the filamentary. It may be that in the haste, which has always seemed to characterise Mr. Edison's efforts to patent every improvement, real or imaginary, which he has made or hoped to make, he had not stopped to reflect when he framed his application for the patent that the filamentary burner would do its work just as well uncoiled as coiled, provided the same length and cross-section were used. It is true that it is said in the general statement of the nature of the invention that the burner is so "coiled or arranged" as to offer high resistance and present a small radiating surface; but this description is satisfied by any arrangement, whether by coiling a considerable length in a small globe or using the same length uncoiled in a large globe, by which sufficient total resistance is obtained from a filament of small diameter. It certainly would not involve invention to omit the coiling and elongate the globe; hence, it is manifest that the invention described is the same thing essentially, whether the coiled form is used or not. The language is satisfied if the burner is filamentary, and so arranged as to offer great resistance and slight radiation, without importing into it anything which is not of the essence of the invention. No precise limitation upon the maximum diameter of the filament can be defined from the specification, or is required as an element of the claim. The specification mentions, by way of illustration, the threads of linen or cotton which become more attenuated after carbonisation, and the carbon wire which, after carbonisation, would be from four to five one-thousandths of an inch in diameter, while the smallest rods of carbon previously known were about a millimetre in diameter, thus having a cross-section fifty times as great as the carbon wires. It is to be implied from the suggestions in the specification that it is to have sufficiently high total resistance for efficient use when the lamps are arranged in multiple arc, and to be used with leading wires of fine platinum. The claim is not limited to a carbon filament made of non-fibrous material. The conductors of the claim are the platinum wires mentioned in the specification. The receiver is the vacuum described in the specification. The peculiar method of securing the conductors to the filament, made a constituent of the first claim, is not imported into the second claim. A more exact interpretation of the meaning of the claim than has thus been indicated is not necessary in the present case, because each of the three lamps representing the kinds used by the defendant embodies the invention of the claim as thus interpreted.

It is of little import what Mr. Edison or his patent solicitor may have thought about the meaning of the claim during the pendency of the application for a subsequent patent, or that Mr. Edison may have supposed a resistance as high as 100 ohms in the burner would be required for use with the means of distribution which he expected to employ with his system of lighting. There are many adjudicated cases in which it appears that the inventor builded better than he knew; where a patent has been sustained for an invention the full significance of which was not appreciated by the inventor when it was made. In the case of the Bell telephone patent there was great room for doubt whether the speaking telephone had been thought of by Mr. Bell when he filed his application for a patent, but the Court said: "It describes apparatus which was an articulating telephone, whether Bell knew it or not." 88 Blatch., 532.

The nearest approach in the prior art to the invention of the second claim is undoubtedly the lamp of Edison's French and English patents with a platinum burner. It seems almost preposterous to argue that the substitution of a carbon filament for the platinum burner of that lamp was an obvious thing to electricians. It would have been, probably, if there had been such a thing as a filamentary carbon in the prior art. But the nearest approximations to it were the ribbon-shaped carbon burner of low resistance of Mr. Farmer (which was not a part of the prior art, but an isolated example known only to a select few), and the low resistance carbon rod burners of the patent of Sawyer and Man.

Undoubtedly the improvements that have been made in the art—such, for instance, as the method of electrical carbonisation of the filament—since Mr. Edison's invention, have been of great value, and the perfected commercial lamp of to-day is far superior to the one which could be made by applying to the description of the patent all the knowledge and skill then possessed by those to whom it was more particularly addressed. But, as was said by Bowen, L.J., in the Court of Appeals in England, "the evidence shows that lamps made solely on the patent will and do succeed, although subsequent improvements have been ingrafted on the original design." It is impossible to resist the conclusion that the invention of the slender thread or carbon as a substitute for the burners previously opened the path to the practical subdivision of the electric light.

The questions which have seemed the most meritorious of those argued at the bar have now been considered. Others, to which no reference has been made, have not been overlooked, and may be dismissed without discussion, and with the single remark that nothing which has been presented by the voluminous proofs and the exceedingly able and elaborate arguments of counsel seems to supply any valid reason for refusing to decree for the plaintiff.

The usual decree for an injunction and accounting is accordingly ordered.

ELECTRIC LIGHTING AT BRADFORD.

At the meeting of the Bradford Town Council, last week, Alderman F. PRIESTMAN, Chairman of the Gas and Electricity Supply Committee, on moving the adoption of the minutes, said that with regard to the electric lighting works, the present works had cost £35,000, and he was going to ask for £5,000 or £6,000 for increasing those works. It was proposed to put down one 300 H.P. engine, and two 80 H.P. engines. The works now were able to supply 3,500 amperes, and with this addition would produce 1,800 more. The proposal to light the Town Hall was before the Council, and would probably soon be carried out, and the Committee had a large number of demands for the electric light current. They had not pressed the matter, for they had the interests of the gasworks—in which a large amount of capital had been sunk—to preserve, but the increased demand was consequent upon the superiority of the electric light. He apprehended that the Council would wish that the Committee should keep pace with these demands.

Mr. J. GALLOWAY thought the Chairman of the Gas and Electricity Supply Committee ought not to have used the word "economy" in his remarks, because the electric light had been a source of loss to the Corporation. If the supplying of the electric light was a paying concern he would support Alderman Priestman, but he could not do so at present.

Alderman SMITH FEATHER appealed to the Chairman of the Gas and Electricity Supply Committee to postpone the proposed addition. He understood that they were at present consuming 6lb. of coal per hour for each horse-power indicated, and he had been informed that the consumption could be reduced to 1½lb. per hour. He was further given to understand that a proposal had been made to the Halifax Corporation to supply a complete electric plant and guarantee a profit of 7½ per cent.; and if that could be done at Halifax it could be done in Bradford.

Alderman PRIESTMAN, in reply to Mr. Galloway, said he considered the expenditure on the electric light works was a wise one. He would not propose any expenditure of public money unless he believed it would be a wise expenditure. Up to December 31, 1889, the loss on the electric lighting works was £1,079; during the half year ended June 30, 1890, the loss was £732; and from that date to December 30, 1890, the loss was £315. That showed clearly that they were now on the verge of making the works pay, and, from the facts and figures he had given to the Council, he had not the slightest hesitation in saying that by the end of next year those works would be paying more than the interest on the money expended on them. He appealed to the Council to complete the installation in the way proposed by the Committee. He believed that it would very soon be the duty of some one to ask the Council to spend an additional sum of money on the electric light works, and that would be the best time to deal with the question raised by Alderman Feather. He thought the Committee was proceeding in the most economical course possible. There had been a complaint in some quarters about the Committee not adopting the alternating current, and in answer to that complaint he wished to state that the direct and continuous current was the one most favoured by authorities on the subject, and was the one which would probably be generally adopted in the future.

The resolution was carried.

PARLIAMENTARY INTELLIGENCE.

HOUSE OF LORDS.—SELECT COMMITTEE.

On Thursday, last week, the St. Luke (Chelsea) Electric Lighting Provisional Order Bill again came before the Select Committee of the House of Lords, presided over by Lord Basing, it having been reconstructed in order that the petition of the London County Council against the amendments introduced into the Bill by their Lordships, at the instance of the Vestry of Chelsea, might be considered.

Mr. Cripps, Q.C., appeared on behalf of the London County Council, in support of the petition, while Mr. Holland, clerk to the Vestry of Chelsea, opposed it.

Mr. CRIPPS, in opening the case for the petitioners, said subsequently to the passing of the Electric Lighting Act, 1888, the Board of Trade wrote to the London County Council that they were anxious to take no definite steps which would have an important bearing on the future policy to be pursued with regard to electric lighting without communicating with the Council, and that they were unwilling to take any action which might hamper them in the future. The result was that nearly the entire area of the County of London had been appropriated for electric lighting purposes to one or more electric lighting companies, and that all these Provisional Orders had followed a "model form" which had been adopted, after much discussion, by the Board of Trade, and generally accepted by the local authorities, so that the law as to electric lighting was in the same form throughout the whole of the County of London. The provisions in force throughout the County of London, as regarded the inspection and testing of electric lines and meters, were regarded by the Council as of exceptional importance. The County

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of London was divided into about forty different parishes, and great confusion and difficulty would result if the laws as regarded the inspection of electric lines and meters differed in various parishes, and were administered by different authorities. The County Council had, under their Acts now in force relating to electric lighting, provided a staff and appliances for the purpose of testing electric lines, and a station for the purpose of testing meters, and he submitted that it was not only important that the provisions with respect thereto should be uniform throughout the county, but that the whole system could be worked more economically and efficiently by means of the establishment of the County Council, as the central authority representing London, than by the various parochial authorities in their own areas. It had been urged that there was in existence as regarded part of the parish of Chelsea a Provisional Order, passed in 1886, under which the Vestry of Chelsea had powers with regard to the appointment of an inspector. He would, however, point out that this Order was passed prior to the creation of the London County Council, and to the passing of the Electric Lighting Act, 1888. He maintained that it was important in regard to this matter that the legislation throughout London should be uniform. The petition of the Vestry of Chelsea appeared to have been based upon a misapprehension. He asked their Lordships to restore the Order to the form settled by the Private Bill Committee presided over by Sir G. Trevelyan.

The CHAIRMAN asked whether it was a fact that, with the exception of the parish of St. Luke, Chelsea, all the operative electric lighting orders in London had been passed since 1888.

Mr. CRIPPS said he believed that every one of them had been passed since 1888.

The CHAIRMAN said the County Council could not deprive the Chelsea Vestry of the powers they possessed under the Act of 1886.

Mr. COURTENAY BOYLE, of the Board of Trade, gave evidence in support of the case for the County Council.

The CHAIRMAN said there was no intention of casting any reflection upon the policy which the Board of Trade had adopted since 1888. The Committee thought that the case of Chelsea was peculiar, and required different treatment.

The Committee, after a short consultation, said they did not desire to hear Mr. Holland on behalf of the Chelsea Vestry. Lord Basing remarked that the Committee had come to the conclusion that the alterations made on the last occasion at the instance of the Vestry must be supported. They, however, desired him to say that they had no wish whatever to call in question the wisdom of the policy of the Board of Trade since 1888. They refused the petition of the County Council, because they believed that the amendments of the Vestry would create less confusion.

The Bill was then ordered to be reported to the House.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *July* 11, 1891.

Electric Traction in Brooklyn.—The electric railway has scored one considerable point in its struggle for admission in the vicinity of New York. The Railroad Commissioners have granted the request, in spite of numerous protests, of one of the Brooklyn railway companies to change its motive power to electricity. The case has been under discussion for some time, and it is only recently that this decision was reached. Undoubtedly further legal measures will be taken to prevent the erection of the overhead lines, but probably without much success.

The New York Rapid Transit Commission.—Very little has been heard of late about the proceedings of the Rapid Transit Commission. Borings have been going on through the lower part of the city with the idea of determining the depth and character of the substratum of rock that will have to be encountered in the carrying out of any tunnelling scheme; and they reveal the fact that a tunnel will not be specially difficult to construct. Meanwhile the building of the cable conduit on Broadway is progressing rapidly, especially in the upper part of the city. The Broadway line obtained permission to change its motive power to cable some time since, although the work has been much delayed, and there were rumours that it would not be carried out at all. Work is now going on with considerable rapidity, and the date named for beginning operations with the new motive power is October 1st. It is very doubtful, however, if the necessary equipment will be completed by that time.

Proposed Electrical Trust.—There is considerable discussion just now about the formation of an electrical trust not dealing in apparatus but in general electrical supplies. With all the conflicting interests at stake, it is very doubtful if any definite and permanent arrangement could be entered into, and present appearances indicate that the affair will settle down into a combination of three or four important houses in this part of the country with a view of controlling a certain portion of the supply trade. The competition in this line has been very severe, and two electrical companies of that sort have collapsed within the past few days.

CORRESPONDENCE.

EXPERIMENTS ON THE ELECTRIC DISCHARGE IN VACUUM TUBES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In *The Electrician* for July 17th there is a description of some experiments made by Mr. Nikola Tesla, which are somewhat similar in character to those shown by me to the Cambridge Philosophical Society, in February, and to the London Physical Society, on their visit to Cambridge, on May 9th. Mr. Tesla seems to ascribe the effects he observed to electrostatic action, and I have no doubt, from the description he gives of his method of conducting his experiments, that in them electrostatic action plays a very important part. He seems, however, to have misunderstood my position, with respect to the cause of these discharges, which is not, as he implies, that luminosity in tubes without electrodes cannot be produced by electrostatic action, but that it can also be produced when this action is excluded. As a matter of fact, it is very much easier to get the luminosity when these electrostatic effects are operative than when they are not. As an illustration of this I may mention that the first experiment I tried with the discharge of a Leyden jar produced luminosity in the tube, but it was not until after six weeks' continuous experimenting that I was able to get a discharge in the exhausted tube which I was satisfied was due to what is ordinarily called electro-dynamic action. It is advisable to have a clear idea of what we mean by electrostatic action. If, previous to the discharge of the jar, the primary coil is raised to a high potential, it will induce over the glass of the tube a distribution of electricity. When the potential of the primary suddenly falls, this electrification will re-distribute itself, and may pass through the rarefied gas and produce luminosity in doing so. Whilst the discharge of the jar is going on it is difficult, and, from a theoretical point of view, undesirable to separate the effect into two parts, one of which is called electrostatic, the other electro-magnetic; what we can prove is that in this case the discharge is not such as would be produced by electromotive forces derived from a potential function. In my experiments the primary coil was connected to earth, and, as a further precaution, the primary was separated from the discharge tube by a screen of blotting paper, moistened with dilute sulphuric acid and connected to earth. Wet blotting paper is a sufficiently good conductor to screen off a stationary electrostatic effect, though it is not a good enough one to stop waves of alternating electromotive intensity. When showing the experiments to the Physical Society I could not, of course, keep the tubes covered up, but, unless my memory deceives me, I stated the precautions which had been taken against the electrostatic effect. To correct misapprehension I may say that I did not read a formal Paper to the Society, my object being to exhibit a few of the most typical experiments. The account of the experiments in *The Electrician* was from a reporter's note, and was not written or even read by me. I have now almost finished writing out, and hope very shortly to publish, an account of these and a large number of allied experiments, including some analogous to those mentioned by Mr. Tesla on the effect of conductors placed near the discharge tube, which I find, in some cases, to produce a diminution, in others an increase, in the brightness of the discharge, as well as some on the effect of the presence of substances of large specific inductive capacity. These seem to me to admit of a satisfactory explanation, for which, however, I must refer to my Paper. I am glad to be able to take this opportunity of mentioning that I

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find that the luminosity produced in a vacuum tube placed near a wire through which a Leyden jar is discharged, was noticed by Hittorf, and described by him in *Weidemann's Annalen*, Vol. XXI., p. 138. As, however, the discharge filled his tube, and did not pass as a ring, I should imagine that the cause of the discharge was primarily electrostatic.—I am, Sir, &c. J. J. THOMSON.

Cambridge, July 18, 1891.

SWIVEL BEARINGS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the Editorial Notes of your issue of 17th you comment on the "egg in the napkin ring" form of self-lining bearing. Premising that the object of this arrangement is quite as much to obviate twist in the bed-plate as bending of the shaft, I should like to offer a few comments. The design is, as you say, "hideous as an expedient," and in my own observation the result is what would be expected. Whether the form of bearing gives trouble is a matter of comparative statement, but that the arrangement is unmechanical is certain, and in practice the seating round the bush wears seriously, and I know of several cases where the bushes have had to be taken out and turned over to bring fresh portions of the line of contact into action. I have seen this result, both in the dockyards with dynamos used by the services, and in central stations. It is for this reason that in the steam dynamos made by Messrs. W. T. Goolden and Co., true spherical-seated bearings have been adopted with most excellent results. The brush has a spherical centre, seated on a spherical bed cast in hard white metal, fitting the sphere all over. After two years' heavy wear I have failed to detect any deterioration in such bearings.—Yours, &c.,

LLEWELLYN B. ATKINSON.

Woodfield Works, Harrow-road, W.

TRADE NOTES AND NCTICES.

TENDERS ACCEPTED.—The London County Council have accepted the renewed tender of Messrs. H. Binko and Co. for maintaining for three years the electrical installations in connection with the Metropolitan Fire Brigade, for £123. 15s. The firm will also fit up any new installations which may be required, at a schedule of prices agreed upon. The other tenders were—R. Colston, £175; Julius Sax, £395; Pyke and Harris, £500.

ANNUAL DINNERS.—The annual dinner of the *employés* of Messrs. D. Hulett and Co. took place on Saturday last, at Markwell's Hotel, Brighton, the party numbering 86.

——— The *employés* of Messrs. Poole and White (Limited) held their annual dinner on Saturday last, at Taplow, Berkshire, the party numbering nearly 50. An interesting feature of the day's proceedings was the sports.

——— The *employés* of the Fowler-Waring Cables Company held their second annual excursion on Saturday last at Ightham, Kent. More than 100 sat down to dinner; and amongst the sports indulged in was a cricket match, in which Mr. George Neill's eleven were victorious.

ALTERATIONS OF ADDRESS.—The Pilsen Electric Company have removed their offices and works from 4, Stanhope-street, Euston-road, N.W., to more central and extensive premises at 80, Leather-lane, E.C., which are being specially arranged for the manufacture of Pilsen arc lamps and all accessories for electric lighting and transmission of power. We are informed that the Company are preparing for the market several new forms and adaptations of the Pilsen lamp, and also an improved kind of arc light carbon.

——— Mr. A. F. Spooner informs us that he has removed his patents, designs, and trade marks agency to 124, Chancery-lane, London, W.C.

AMERICAN COAL CUTTERS.—Messrs. Shippey Brothers inform us that they are introducing a new electric coal cutter, and announce that they are prepared to sell the machines outright, free from royalty, or contract with colliery owners to cut the coal at a fixed price per ton.

ELECTRICAL PLANT AT THE GOLDSMITHS' INSTITUTE, NEW CROSS.—The latest and most improved appliances have been provided for ventilating this Institution by Messrs. Easton and Anderson, who have put down one of their improved electro-motors, driving direct on to a Blackman fan, for supplying the necessary fresh air to the lecture halls. A "Whitehall" dynamo, Prentice's patent, is placed in the space adjoining the electrical laboratory and supplies current to the electro-motor. It has also been proposed to work the bellows of the grand organ, shortly to be erected, by electro-motors, controlled by the organist with magnetic clutches. In this way a large volume of air can be obtained at the will of the player. The "Whitehall" dynamos are driven by the steam engine used for pumping and other purposes, and this will prove an interesting example of how the power may be electrically distributed for a variety of purposes through a large building.

COMPANIES' MEETINGS & REPORTS.

The Eastern Telegraph Company (Limited).

The thirty-eighth half-yearly ordinary general meeting of the Eastern Telegraph Company (Limited) was held at Winchester House, Old Broad-street, on Thursday, July 16, 1891, under the presidency of Sir John Pender, K.C.M.G.

The SECRETARY (Mr. George Draper) having read the notice convening the meeting, and the minutes of the last meeting, which were confirmed,

The CHAIRMAN said: Gentlemen, you have had the report in your hands for some days, and I presume that you will take it as read. The report is a very full one, and contains an amount of information which will enable anyone who reads it to understand the movements and transactions of the Company. As usual, I shall go through the report, and refer to some of the eading points in it.

The receipts for messages during the six months ending March 31, 1891, amounted to £349,749, as against £348,624 for the corresponding period of 1890, showing an increase of £1,125. The total working expenses for the half-year ending March 31, 1891, amounted to £102,020, as against £98,477, being an increase of £3,543. Included in this year's figures, however, is the item of "special repairs to Alexandria buildings," £3,823, to which I referred at the last meeting. Several of the items show an increase, while others show a decrease. Before I give you the details, I think I may point out that the Alexandria buildings are a very fine block of buildings indeed, but unfortunately, dry rot got into them, and we had to take out the rotten deals and to put in iron. In other words, we had to make very extensive and very effective repairs, for our Alexandria establishment is a very large one, employing a great many hands, and one in which we have to put up our staff. It is a building that does great credit to the Company, and one we thought it was absolutely necessary to put in a thoroughly effective state, both as to the soundness of the building and its sanitary state as well. We have also, I may tell you, in this block of buildings a number of shops which we let off, and altogether it is a building which the Company has every reason to feel satisfied with.

The general expenses in London were £9,503, against £8,726, being an increase of £777, the principal in advertising and stationary. The working expenses at stations amounted to £75,003, against £72,677, showing an increase of £2,326. The necessary increase in the number and the additional pay and allowances granted to some of our foreign staff, to which I referred at our last general meeting, account for the increase in salaries and rent, fuel and light. The amount carried to the maintenance ships reserve fund is £3,000, against £5,000. We have had three of our ships—which is a very remarkable fact—at one time in London. I wish we had been able to keep them there, because our ships are never better employed than when they are in London doing nothing. Two of these vessels sailed the other day, and all of them are in thorough order. Although they are ready and able for work we would much rather that the ships should lie idle. Still, we keep them in such condition that they may be employed at a few hours' notice. To the Staff Endowment Assurance we put £2,366, against £1,688, being an increase of £678. Up to last year a certain number only of our staff had taken advantage of this Assurance scheme. The Directors, however, after 10 years' experience of its working, were so convinced of the benefits it conferred on the staff that they urged the remainder to join, and I am pleased to say that nearly the whole of the staff are now contributing members. This is an important point. All Government offices and most other important institutions generally make some arrangements whereby their staff is assured. Above all it is necessary in our system to have an efficient staff. We get the best men and we can only keep them by making them as comfortable as they could be in any other service. That is our policy, and so far it has succeeded. Now, by our system our men at 50 years of age can retire with a certain amount of money in their pockets. A man at 50 years of age in our service is not so valuable as a manipulator as a young man. Such men have an opportunity, by this fund, of retiring with something in their pockets, and starting afresh in life, if they wish to do so.

The expenses attending the repairs and renewals of cables amounted to £53,144, against £47,520, being an increase of £5,624. On reference to Abstract C, page 7, of the accounts, full particulars will be seen of the work performed by our ships during the half-year. The chief expense has been incurred in connection with the Red Sea cable, laid in 1870. We have succeeded in the removal of all the known weak parts and have laid in new cable, and it is believed that this line, which has been working since the formation of the Company, can still be kept efficient for a number of years, thereby increasing the security of telegraphic communication in the Red Sea. It is also encouraging in this way: there was a time when

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people said that 10 years was the "life" of a cable; and then it got to 15 years. Here, however, is a cable that has worked for 21 years. We have taken out of it some weak parts and we have put in stronger parts, and we have now a thoroughly efficient cable. Perhaps experience may teach us that a cable may live for considerably over 20 years. All this is for the benefit of our Company.

After providing for all expenses and interest charges against revenue, we are able to recommend a final dividend at the rate of 5 per cent. per annum, and a bonus of 1½ per cent. for the year ending 31st March last, and carry £95,000 to general reserve fund, which amounts to £534,650 after the appropriation of a further £100,000 to the cost of the Suez-Perim-Aden No. 4 cable. I think you will agree with me that is a very satisfactory state of things, and I think as I go on I shall be able to show you that the policy we have pursued in adding largely to our reserve fund has been a very wise one.

Having dealt with the revenue and expenses, I will now give you some information about the capital expenditure on new cables and the financial arrangements incidental thereto. At the meeting in July last year I showed you the necessity of laying a new cable in the Red Sea from Suez to Perim, and from Perim to Aden, at a cost of £250,000. At the general meeting in January last you were informed that in anticipation of the largely increased traffic with Australia, consequent on the reduction of rates between Europe and certain Australasian Colonies, we had decided to lay a triplicate cable between Aden and Bombay of such a capacity as would give us a considerable margin of carrying power, to deal with any increase of traffic that might be at all likely to take place during the next few years. It has always been our policy to keep ahead of the carrying requirements of the Company, and it is satisfactory to be able to say that the encouraging results of the traffic since the reduction of rates to Australia has fully justified the foresight and prompt action of the Directors. To add to the security of telegraphic communication with Suakim, we have considered it advisable to duplicate the connection with that port by cutting into and diverting our No. 2 Suez-Aden Cable. This has caused an expenditure of about 226 miles of new cable. Notwithstanding these important and expensive operations, we do not anticipate any permanent additions to the capital account whatever. We hope to be able to meet this expense by appropriations from time to time out of our reserve fund. Gentlemen, the importance of what I am stating to you, viz: keeping down our capital, and of maintaining our power to pay you annually dividends such as we have done, is, I think, a policy of which you must all approve, and that is a policy which, I repeat, is the great strength of this Company. I shall show you further on that we have duplicated every cable. With the temporary assistance of the Eastern and South African Company, in which we hold fifty-nine sixtieths of the share capital, we shall be able to meet the payments as they fall due to the contractors without disposing of our reserve fund investments to any great extent. The financial transactions will take about four years to complete, and it is estimated that, at the end of that time, our position will be as follows:—The additions will have been paid for, and the whole amount applied out of the reserve fund. The Eastern and South African Company will have been repaid, and our capital account will stand at practically the same figure as at present—provided, of course, that no further extensions of our system are considered advisable. It is reckoned that the amount taken out of the reserve fund, from time to time, up to the date of the completion of these arrangements, will be about £1,500,000, and the balance remaining in the fund will be about £500,000. It is hardly necessary for me to say that the Company will, in consequence, be in even a better financial position than it is to-day.

During the financial year to 31st March last we have expended 769 knots of cable, while the amount used on repairs has been 460 knots. A portion of the cable expended was used in putting the Red Sea line in, as far as we know, efficient order. It may interest you to know that our ships have sailed during the year ending 31st March last, one way and another, no less than 112,189 knots, showing that they are constantly employed; and, indeed, without these ships we could not possibly exist.

We have now got all our cables duplicated, as I have already said. We have got four cables between Suez and Aden, and three between Aden and Bombay. These are very important sections. Altogether we have now a system of 26,093 miles, as against, in 1870, a mileage of 8,434, which practically represented the capital originally involved in this concern. Therefore this large addition from 8,434 miles in 1870 to 26,093 miles in 1891 has been done with an increase of less than £2,000,000 in the capital, and without in the slightest degree interfering with your dividend. A large amount has been taken from revenue, and at the same time we have materially added to our reserve fund. I think that is a state of things with respect to your property which it would be very difficult to beat.

I have now given you certain details which you will be able to carry away in your mind, and from the last point to which I have referred you will see that your property has been very safely protected. I may refer to another point—namely, that in our African traffic alone this last year there was a decrease of something like £49,000 compared with the amount we received from that source two years ago, when, however, there was a great deal of excitement in Africa, and money was expended very freely. Communication between Africa—the Cape, and Kimberley—with London was very active indeed. I cannot tell you the number of Mining Companies in London that were established, and they were all more or less in connection with Kimberley; and, consequently, we had a very considerable amount of traffic. For the moment that traffic does not exist, but there has been a growing legitimate traffic. The population has been increasing there. You must remember that there are cycles of prosperity, and cycles of rest, and I think the cycle of rest is now prevailing, and that we may look forward to the spirit of enterprise reviving. It is in the hands of Englishmen, and there is no doubt that the Cape is one of the future countries to which we have to look, not only for gold, but also for a largely increased consumption of British merchandise. There is another point which I think I may mention as interesting to you, namely, that these African cables in a certain period will belong to the Eastern Company—they practically do so now; but at the end of the period all the debentures will have been redeemed, and we shall, as I have already said, hold fifty-nine sixtieths of the capital. Now, as I told you, we have put our cables into thoroughly efficient order, believing that the reduction of rates to Australia was going to produce a large increase. That increase up to the present time—the reduced rates have only been in force three or four months—has been on the whole satisfactory. We have not recouped ourselves yet, and I do not suppose we shall do so within 18 months or two years; but I think I may say that we have so far recouped ourselves that when the end of the year comes we shall go on with the experiment. The Cape has applied to us to be put on the same footing, but that requires some consideration and some negotiation. I should like to see one experiment fairly tested before we enter upon another, and meantime things are not so very active at the Cape. Still, I hope and believe that this may eventually come, and when it does come it will give us what I call a Cape guarantee for our dividend, and that will add materially to the value of our shares; at least, that is my opinion.

When I last addressed you I told you that I was going to visit some of our stations in the Mediterranean, I have done so; and I am not the only person who says this, but all whom I have met who have visited these stations say they are most creditable to the Eastern Company. We have a good class of young men, our establishments are well conducted, and, altogether, we ought to be proud of the way in which our business is conducted in the Mediterranean. I went from there to Constantinople. I found there a very great disposition on the part of the Turks to keep up our friendly relations, and we opened certain negotiations which have proceeded, and through which we may be able to lay before you a matter for still further strengthening our relations with foreign Governments, and promoting our business. I then went on to Athens, and I found a very warm interest taken in our affairs in the Kingdom of Greece. Altogether I was assured that the way in which your business was conducted was thoroughly and entirely satisfactory to the Governments with whom I had the pleasure of conversing.

I think I have given you pretty well all the particulars that I desired to communicate to you, and, with these remarks, I beg to move the following resolution:

"*That the printed Report and Accounts of the Directors to 31st March, 1891, submitted to this meeting, be and the same are hereby received and adopted. That a dividend on the preference shares of the Company to 30th June, 1891, at the rate of 6 per cent. per annum, be paid, less income-tax; and that, in accordance with the Directors' recommendation, a dividend be, and is now declared of 2s. 6d. per share, with a bonus of 3s. per share, both free of income-tax, on the ordinary shares of the Company, making, with previous payments, by way of dividend on account, a total payment of 6½ per cent. on those shares for the year ended 31st March, 1891.*"

The VICE-CHAIRMAN (The Marquis of Tweeddale): I beg to second that.

The CHAIRMAN: If any gentleman wishes to ask any question before I put this resolution I shall be very glad to answer him to the best of my ability.

Captain GOODSALL: You spoke so favourably with respect to the Staff Endowment Assurance, that I should like to ask this question: Does that embrace the officers and commanders of the ships?

The CHAIRMAN: I see some of the commanders here to-day, and I think they will tell you that they are very well satisfied with the position they hold. During a voyage some five or six years ago across the Atlantic, the Captain of one of those vessels said to me: "Oh, if you would only take me into your service! I should think it not only a great honour to serve your Company, but a comfort which it is impossible to find here."

Captain GOODSALL: I grant all that, but I say why should not the officers of the ships have the privilege of sharing in the benefits of the Endowment Assurance? It would make no difference to the Company. May I also ask whether the last Aden-Bombay Cable was laid to the south or the north of the other two?

The CHAIRMAN: I think you will give us credit, after our long years of experience, that we should lay the cable where our engineer thought best.

Captain GOODSALL: The question I asked is whether this cable is laid to the south or the north. The south is the best side.

The CHAIRMAN: The answer I give you is this—that these matters are very carefully considered. They are not only discussed by our own experts, but we have the advice of a leading engineering house in London—Messrs. Clark, Forde, and Co., and they are the people who are actually representing your interest outside of the Board. When cables are being made, and until they are laid and in working order, they are put under the charge of our engineers, so that, apart altogether from the way in which the Board deal with this matter, we have independent men to look after the practical part of the business, just as we have auditors to look after our accounts.

Captain GOODSALL: Is this cable laid to the south or north of the other two?

The CHAIRMAN: To the south.

Captain GOODSALL: That is what I wanted to know.

The CHAIRMAN: Those in favour of the motion which I have read will please hold up their hands. To the contrary. Carried unanimously. That concludes the business of the meeting.

Mr. W. GRIFFITH: The position of the Company is so favourable that I think we should not separate without following our custom of passing a

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vote of thanks to our Chairman and Directors. The resolution has been so often passed that it may appear somewhat formal, but I think on this occasion it will be thoroughly cordial. If we look at the report we cannot but be satisfied with the dividend and bonus which has been declared; and, further than that, I think we ought to thank our Chairman and his colleagues for the very sound and sensible policy which they have adopted. It is a great thing that many of these improvements in our position have been paid for out of our reserve fund, and that there has been comparatively so little necessity to increase our capital. Our capital keeps low, our shares are improving in value, and if this dividend and bonus continue, I think we have great cause to thank those who have been so instrumental in bringing about such desirable results. I move a vote of thanks to the Chairman and the Directors.

Mr. MAYNES: I beg to second that.

Mr. GRIFFITH put the motion to the meeting, and it was carried unanimously.

The CHAIRMAN: I beg to thank Mr. Griffith for the way in which he has proposed this vote of thanks to myself and the Directors. We have endeavoured to carry on this business in a way which would be not only satisfactory to our shareholders for the moment, but also to make it an enduring success; and, as far as one can see, our policy has been eminently successful in that direction. I do not suppose that at the present moment there exists a more complete system of submarine telegraphy; in fact, it is impossible. This is the most complete system of submarine telegraphy that has existed, and we hope to keep it still the first system. I will just say one word which you may carry away with you. We have come of age. It is 21 years since our main cables were laid, and in that period we have almost touched every port where the British flag flies. That is a work which we have done in 21 years, of which you have helped us by finding the capital, and we, who have been instrumental in carrying it out, ought to be very well satisfied. We have attained our manhood, and I hope that it will be used as advantageously as our youth.

The proceedings then terminated.

The Direct United States Cable Company (Limited).

The twenty-eighth ordinary general meeting of this Company was held at Winchester House, Old Broad-street, E.C., on the 17th inst., under the presidency of Sir John Pender, K.C.M.G.

The SECRETARY (Mr. T. Finnis) having read the notice convening the meeting and the minutes of the twenty-seventh ordinary general meeting, held in January last, and the report being taken as read,

The CHAIRMAN then said: I shall, as usual, go over some of the figures of the report before I make a few general remarks on the position of the Company during the last six months. The revenue for the half-year to the 30th of June, after deducting out-payments, amounted to £37,353, and the working and other expenses, including income-tax, but exclusive of the cost of repairs, absorbed £18,113, leaving a balance of £19,240 as the net profit of the half-year, making, with £5,510 brought forward from the previous half-year, a total of £24,750, which has been appropriated as follows:—interim dividend of 3s. 6d. per share for the quarter to the 31st of March, £10,624; proposed final dividend of 3s. 6d. per share to the 30th of June, £10,624; balance proposed to be carried forward, £3,502. That makes the total of £24,750 which I mentioned. The revenue for the past half-year has shown a falling off of £2,664 as compared with that of the corresponding period of 1890, due to slackness of business, to some curtailment of trade owing to recent fiscal arrangements of the United States Government, and to the temporary loss of traffic with the West Coast of South America, through the war in Chili. In the expenditure in London, as shown by Abstract "A" in the accounts, most of the items remain practically unaltered. There is an increase of £90 in the salaries, and a reduction of £82 in the printing and stationery item, these expenses on the whole being £19 less than in the same period of last year. The expenses at stations show an increase, on the whole, of £468, due to our responsibility for the full cost of the New York (Broadway) office for the complete half-year (as explained in paragraph 6 of the Report to the 30th of June, 1890), and to the establishment of a new branch station at 21½, Spruce-street, New York. The cost of repairs during the half-year has amounted to £2,188, which has been charged to reserve fund account, as usual. On the other hand that account has been credited with £4,365, for interest on the investments, leaving the balance of the reserve fund account at the increased figure of £254,854. The investments, which have been increased from £234,993 to £244,652, are entered in the balance-sheet at cost, which is a figure considerably below their present market value. Gentlemen, that gives you something like the hard facts connected with the working of the Company during the last six months. I have been looking over the notes of the last two or three half-yearly meetings, and really I have told you so much in the past that it is very difficult indeed to say anything new on the present occasion. With the existing depression of trade and the kind of cloud which is hanging over commercial enterprise generally, we are affected, and are participating, to some extent, in the evils resulting from such a state of things. I have always said on these occasions that telegraphy is a good barometer of trade. With buoyant trade we have buoyant traffic; with depressed trade we have people buttoning up their pockets. While telegraphy is, more or less, a necessity, it is a luxury in commercial enterprise, and merchants endeavour, as far as possible, to cut down expenses when they find that their incomes are not such as they have been accustomed to. There is one thing which I have pleasure in stating—that with all the difficulties and all the troubles that have surrounded submarine telegraphy in the Atlantic for some time, I think I may say, with perfect safety, that there is no company at the present moment occupying a better position than the Direct United States Cable Company. I will show you that by figures. There is no better field for telegraph enterprise in the world than that of the Atlantic, for there are the two great English-speaking people to communicate with one another through the wires at either end, and the enterprise of the English people is proverbial. They dominate the commercial world, and when they are active they are particularly active in the United States; and I am looking forward—not without some reason, I think—to a renewed amount of energy on the part of our kinsmen beyond the sea. There is an exhibition coming forward there, and no doubt they will try and make that the finest thing of the kind which has yet been done, and I believe that they will do it. To do it requires, however, a great deal of energy, a great deal of time, and a great deal of money, and I believe we shall get some portion of that money on our system. It is always pleasant to talk to people who are interested in any particular subject, and you, as shareholders of the Company, are directly interested in this system. There is an old saying—I believe it is a German saying—that it is always pleasant to send you away with a pleasant taste in your mouth; and I am going to show you that, as far as this Company is concerned, you may be satisfied that, as regards Atlantic submarine cables, your property is about the best of the whole. The figures I am going to mention to you are interesting in this way—that they show you exactly the market value of the different companies' cables at the present moment. I am sure it will interest you. It always interests me when I look at it, and I do not think that I have ever before given you these details. I will, therefore, do so to-day. I will first of all take the Anglo-American Company. The original capital of that Company was £7,000,000, and its market value to-day is £3,220,000. Their reserve fund is £980,948. The present market value of their property, less the reserve fund, is £2,239,052, or equal to, per cable—this is the point I wish to bring you to—£559,763. That is, each of the cables of the Anglo-American Company stands at the present moment at a cost of £559,763. They pay a dividend of 2⅞ per cent. upon the £7,000,000, but this yields to the investor, at the present price, 6¼ per cent. Now I will take our position. Our original capital was £1,214,200, and its market value to-day is £652,632. Our reserve fund is £254,854. The present market value of our property, less our reserve fund, is, per cable, £397,778. Our dividend, as you know, is 3½ per cent., and, upon present prices, that is equal to a dividend of 6½ per cent. The capital of the Western Union Company is £2,800,000, and its market value is £2,240,000. They have no reserve fund. The present market value of their property is £2,240,000, equal to, per cable, £1,120,000. Their dividend is 5 per cent., but it is guaranteed by the Western Union; and they yield to the investor, their capital being at a discount, 6¼ per cent. The next company I will deal with is the Commercial Company. Their capital is £1,643,200, and they have debentures amounting to £320,000, so that altogether their capital is £1,963,200, the market value of which is £2,080,992. Their reserve fund is £220,000. The present market value of that property, less the reserve fund, is £1,860,992, equal to, per cable, £930,496. Their dividend is 7 per cent., but the yield to the investor, at present prices, is 6⅝ per cent. With regard to the French Company their capital is £1,680,000, and its market value is £428,400, which is equal to, per cable, £428,400. That Company has only one cable, and it has no reserve fund and pays no dividends. Now, this is an extraordinary position, and I will repeat this part of it—that each cable of the Anglo-American Company, according to the present market value of the property, less their reserve fund, is £559,763, whereas in the case of the Direct Company, it is only £397,778. That is an enormous advantage for the Direct Company. We stand at the lowest possible price. We could not possibly put down a new cable for the same price as the cable stands at the present time. I therefore think that we may congratulate ourselves that, what with the value of our cable, and our reserve fund of £254,000, we are by far the best property of any in the Atlantic. I think you will agree with me in that, and I think it is a circumstance which should leave a pleasant impression on your mind. I only wish that I could add to that that the prospects are such that we may soon return to our old dividend of 5 per cent., but when we were paying that dividend there were only about six cables in existence. Since that time, however, the cables of the Western Union have come in, as well as two more cables of the Commercial Company. We never earned at any time more than about £950,000 a year; we never got up to £1,000,000 for the whole of the Atlantic traffic. That, too, was at 2s. a word. At the present moment we earn practically £900,000, or very nearly as much as at the former rate, but this amount is divided among 10 cables instead of among six. In addition to that, science has given us the power to transmit over our cables just double the quantity of traffic that we used to be able to send over a single cable. The duplex system has doubled the power of carrying, and, therefore, I may say that, at the present moment, we have practically 20 cables in the Atlantic to do the business and to be remunerative. Believing, as I do, in the growth of submarine telegraphy, nevertheless it takes a long time to make up an amount of traffic to fill 20 cables as compared with six or eight. I think you will all understand that point. Now, we make the greatest possible effort to gather traffic, and there is a competition, and an active competition, going on just now, probably more active than profitable, among the Atlantic cables to get hold of the traffic. When I tell you that active competition has cost the companies between £30,000 and £40,000, it shows you that pushing and energy to obtain traffic may be carried a little too far. I believe it has in the present instance been carried a little too far, and whenever a matter like this is carried to a point when it is not profitable, I think you should consider whether it is best to alter your tactics. I never like to sow where I cannot reap, and I never like incurring expense which I cannot recoup by a profitable return. This is a question that requires the consideration of all the companies, and I think that, as things are going on now, the day is not far distant when we may have this question thoroughly considered among the companies. There is another cause accounting for the depression in Atlantic telegraphy. At the present time I may tell you that there is a positive

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decline in Atlantic telegraphy, and it is said that the McKinley Bill has had something to do with it. I think there is no industry in this country which has not thrown a stone at the McKinley Tariff Bill, but I think the parties who are likely to suffer more than any other people by it are the people of the United States. The idea of any one nation living on itself alone—upon its own resources—is the greatest fallacy, and we destroyed that fallacy in the free-trade principles which we adopted many years ago. I therefore think that that will practically come to an end in time. There is one thing, I think, that you may rest assured upon—that the world can no more do without submarine telegraphy than it can do without food. The populations of the different countries where commercial enterprise exists are all—more or less—leaning on the old country. They must come to us; we are the banking institution of the world, and they must lean on us. Submarine telegraphy, therefore, which connects the old world with the new, must always be a growing factor in civilisation. That is the broad view which I take of submarine telegraphy, and I only regret that at the present moment, in regard to the particular part of the business in which we are interested, there is just a trifle too much—there is a plethora of power to carry on the work; and until we fill that up I cannot hold out any great encouragement of an increased dividend, but that it is gradually filling up and gradually growing I have not the slightest doubt in my own mind. Those who came into this Company at the reduced price of the shares are getting a very handsome dividend on the money which they have invested in it, and, therefore, I think they will be satisfied to rest and look on in the hope that even that dividend which they are receiving now, handsome as it is, may be increased in the future. There is only one other point which I have to say a few words upon,—I refer to the French suit. I was asked about that at the last meeting. Since then the French Courts have, I believe, decided in our favour, but there is an old saying, that it is very difficult to get a bone out of a dog's mouth, and it is very difficult to get money out of any French institution, particularly if it is to come to England. Therefore, I do not wish to buoy you up in any way on this point. We have gained the suit, and that shows that we were right in going into it, but what money we are going to get out of it I must leave to mention six months hence. I now propose:

"That the report of the Directors, dated July 8th, 1891, together with the statement of accounts to June 30th, 1891, annexed thereto, be, and the same are hereby received and adopted, and that a final dividend be now declared of 3s. 6d. per share, free of income tax, making, with the interim dividends already paid, a total dividend of 3½ per cent. for the year ended June 30th, 1891."

Mr. WILLIAM FORD: I beg to second that.

Mr. JACKSON said that the Chairman had given them some very interesting remarks in reference to the return on their investment in the Company as showing a result more satisfactory than that of any other Atlantic cable property. He had, however, been very much surprised to hear the Chairman quote the Commercial Company, and say that the Direct were doing better than that Company, for the net return on the capital subscribed to a company was the test of its success. In judging of the prosperity of a company the net return was the *crux* of the whole question. The Commercial Company, which was the youngest competitor and with the least experience, was making a 7 per cent. dividend, while its shares were above par. He did not think that any amount of figures could alter that fact and reduce that Company to a condition inferior to that of any of the Atlantic Cable Companies. He supposed that the lawsuit referred to had been in the hands of the Anglo-American Company, though, no doubt, with the advice of the associated companies. He had been in hopes that the Chairman would have been able to say that the award—which they must look forward to, having got a verdict from the Council of State—had been received. He thought that the Pool Companies were bound in duty to press the fact before the French Courts that the intrigues of a man who was discredited as a man of the worst kind had brought about the capture of their partner cable, and if they were to have no compensation for that, he thought that the Boards of the various Atlantic Cable Pooling Companies would fail to do their duty to their shareholders. The Commercial Company had thriven through having strengthened its force through this capture, which was done by an act of a very base kind. Having made these remarks he had much pleasure in supporting the motion.

The CHAIRMAN: I suppose that no other gentleman has any remark to make, and therefore I will reply to Mr. Jackson. I think, if I remember rightly, in speaking about this lawsuit six months ago, I said that I thought I had used language about it in Paris that might have led to an affair of honour. I am not going to say much more than that. We are in the hands of the French Courts, and are being advised by French legal gentlemen of the highest standing, and we are more or less bound to abide by their decision. This is a question, as Mr. Jackson knows, which is entirely in the hands of the Anglo-American Company. We are, no doubt, interested in it—we participate in the result—but we are not in any way connected with the conduct of the suit except as we may say "Yes" or "No" to any proposal that may be made with regard to it by the Anglo-American Company. That Company has consulted us all through in this matter, and they continue to do so now. The secession of the French Company from the Pool was a disadvantage in so far that it enabled the Commercial Company to command a certain amount of French influence and a certain amount of French traffic, and gave them for the time being an additional cable to carry on their competition against the seven other cables. In that respect there is no doubt at all that it did us serious harm, and in all probability the damages will accrue on this, as on other points. As to the other question which Mr. Jackson raised, I had a note about it, but I thought it was not worth while to draw attention to the very anomalous position of the Commercial Company to which he has referred. They are paying their dividend on their full capital. We pay a dividend on our full capital, but it only gives a result to present investors equal to the dividend paid by the Commercial Company. What is the position of the Commercial Company? It is, comparatively, a private Company. It has a newspaper connected with it on the other side of the Atlantic. Why do they get so much more traffic than we do? It is in this way. When they started first they went to the different telegraphing people that they perfectly well knew, and they said to these people, "If you will stand by us for a certain time, we shall reduce the tariff from 2s. to 1s. 8d." The result was that the people who had made a promise to support the Commercial Company were bound, to a great extent, to support that Company against the other companies, believing that they were the pioneers of the reduction of the tariff. They have, therefore, had a decidedly larger share of the traffic than we ever expected they would get. However, the obligations that were entered into at that time will come to an end, and the cable company which has the largest number of lines, and which can do its business best, is certain, in the long run, to get the telegraphing business into its hands. I think the result of what is going on now, and the extraordinary anomaly that exists as to the different cables, will very soon be adjusted. All I can say is that I should be very sorry—extremely sorry, indeed—to have my money invested in the Commercial Company with its stock at a premium, as against the Pool Companies, with their seven cables and all their properties at a discount of from 50 to 20 per cent.

The motion was then put to the meeting and carried unanimously.

Mr. E. M. UNDERDOWN, Q.C., then proposed the re-election of Sir John Pender as a member of the Board and Chairman of the Company. It was, he said, unnecessary for him to say any words with reference to Sir John Pender's conduct of the business of the Company, or of the business of the other companies with which he had to do. A most remarkable statement was made by their Chairman on the previous day, at the meeting of the Eastern Telegraph Company, which he (the speaker) understood had tripled the length of its system without calling on the public for one penny, and had made this magnificent addition out of earnings. That was not the only achievement of Sir John Pender, but of this all who were in the telegraphic world were well aware. With reference to the point raised by Mr. Jackson, as to the amount of the dividend on the capital of this Company, he believed that that gentleman was a shareholder in the Company before he himself was, and he believed that he (Mr. Underdown) was a shareholder in the Company before Sir John Pender. Therefore Mr. Jackson's shares and those of himself stood at a rather higher figure than they would like to see them, but he thought it was their duty to their Chairman to say that they must be taken to start from the year 1877, and he believed that very few remained among them who were holders of the original shares.

The CHAIRMAN: Five per cent. or six per cent.

Mr. UNDERDOWN, continuing, maintained that the Directors had increased the nominal value of the shares—that was, their equitable value as they stood at that time. They had maintained a very respectable value for them as they now stood, and if we pay 6¾ per cent. on that, then Sir John Pender and the Board were doing very nearly as well as the Commercial Company, if they took the point they started from. However this might be, it must be very satisfactory to them to know that their little Company had maintained the position it had, as between the other companies, and this was a fact due exclusively to the services of Sir John Pender, who had contributed so much to the general prosperity of submarine telegraphy.

Mr. WILLIAM FORD seconded the resolution, which was carried unanimously.

The CHAIRMAN: For the very complimentary way in which Mr. Underdown has again brought my name under your notice I thank him, and I thank you for accepting Mr. Underdown's motion in the unanimous way in which you have done. The reason why I have devoted so many years to telegraphy has been that I have regarded the work not only as a labour of love, but of deep interest, and I have given to it deep anxiety and active thought. As I have stated, we have had difficulties in the Atlantic, which is the finest field in the world for submarine telegraphy, for whereas at one time the Americans would not look at the enterprise, they at last came in in a volume and upset the pioneer. I have no doubt, however, that that is a matter which will right itself. I believe in English energy and English dogged perseverance, and I believe in this work upon which we are engaged. I have not now a very long term before me, but while I have the energy which I possess to-day, I intend to use it for maintaining English right and English might whenever it may be necessary. Continuing, the Chairman proposed the re-election of Mr. William Ford as a Director of the Company. He referred to Mr. Ford's recent severe illness, owing to an attack of influenza, and congratulated him and the Company on his recovery. He believed that Mr. Ford had never been absent from one of their meetings during the time he had been connected with the Company. His colleague's energy as a Director was very great, and he was one of those men who are always endeavouring to do what is right and just for the interests which he represented.

Mr. CHARLES MEARA seconded the resolution, and it was carried unanimously.

Mr. FORD, in reply, briefly expressed his grateful appreciation of their kindness, and said they would pardon him on that occasion for saying nothing further.

On the motion of Mr. W. S. CUFF, seconded by Mr. JACKSON, the Auditors, Messrs. J. G. Griffiths and John Sawyer, were re-elected.

The CHAIRMAN then intimated that that finished the business of the meeting.

Mr. JACKSON said he thought it was a duty they all owed to the Chairman to thank him and the Board for their management of the Company's affairs. At the same time he desired to repeat his opinion that

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while 3½ per cent. was very good for a guaranteed or preferred dividend, it was not all that they could wish as ordinary shareholders.

Mr. W. GRIFFITH, in seconding the motion, said it might be that those who joined the Company when the shares were high might not be altogether satisfied, but the later shareholders had strong reason for being satisfied with the present and with the good hopes which were held out for the future, and those hopes were sure to be realised under the present able management. Few persons possessed such ability and capacity for conducting business as Sir John Pender and his colleagues, and it was with much pleasure he seconded the resolution.

The motion was carried unanimously.

The CHAIRMAN: In the name of my colleagues and myself I thank you. Nothing pleases me more than to have that sort of criticism which Mr. Jackson brings forward from time to time. I think we all require a little pricking up occasionally. It does us no harm, and therefore I accept Mr. Jackson's principle of using the spur sometimes. I have, however, told him that we have such a plethora of cable power in the Atlantic just now that it is very difficult indeed to bring the telegraphing public up to the scratch; and, after all, they are the people who are to give us the increased returns which we want. I hope—and it is a natural hope—that we shall participate in such returns, but we have such a power to carry the traffic—so much more than we really want for carrying it—that until the two factors, supply and demand, get a little more assimilated, we cannot hold out any great hope of increasing the dividend on our original capital. I thank you very much, and I hope that we shall have the pleasure of meeting you often, and of having as pleasant a discussion as we have had to-day.

The proceedings then terminated.

The Edison and Swan United Electric Light Company (Limited).

The annual meeting of the shareholders in this Company was held on Tuesday, at the Westminster Palace Hotel, Victoria-street, S.W., under the presidency of Mr. J. S. Forbes.

The SECRETARY and MANAGER (Major S. Flood-Page) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, we have to apologise to you for bringing you to Westminster. The fact is that the City Terminus Hotel, where we usually hold our meetings, is so exceedingly busy that they could not give us a room, and so we came here. The report and accounts have been printed and circulated, and I suppose you will take them as read. (Taken as read.) Well, then, taking them as read, I assume you know all about them. I do not know whether any gentleman has gone through the agreeable exercise I have done during the last 24 hours of reading all the reports from the beginning—that is since 1884. We are now dealing with the eighth complete year of the undertaking, and I discovered a very singular thing, that all the early reports gave what is called very full information. I have been conversant with reports of different companies for a great many years, and I find that it is the characteristic of all those reports in that where the dividends are short they are long. It seems to indicate this, that when a company has emerged as we have done from some of the preliminary difficulties and trials, there is very little to say. It is your acts, not your words, which help you then—how much profit you have got. Happily for us, our reports gradually diminished in length almost as the dividend has increased in amount; and this report before you to-day is one of the shortest we have ever had, and, I hope you will think, as we do, one of the most satisfactory, because it reveals one or two primary things of some importance, namely, that the bulk of the business has increased and the profit has increased and we are enabled happily to dispense in respect of the year and of the arrears accruing due to the "A" shareholders a larger amount than we did last year and than we did in the preceding year. That is the whole of the story. However, one may enlarge upon it, and call your attention to the details, I have been an apologist for so many reports and accounts, that when there is nothing to say I am rather non-plussed; the whole of the story lies in the figures. Well, now, the figures, so far as they concern any joint-stock company's accounts, are not quite so full as those with which I am in the habit of dealing; but the essence of them lies in the profit and loss account, which is the first in this report, and there you will see on the one side the income and on the other the cost of obtaining it. I propose to take you through the income, in order to compare the year with which we are dealing with the preceding twelve months. The first item is by sale of lamps, fittings, royalty on holders, and so on, £143,229. 14s. 11d. Now, the corresponding heading last year revealed the figures, £118,865. 15s. 1d., so that the amount of sales has increased by £24.364. The next item of revenue is interest account, £427. 12s., against £1,442. 17s. 1d., or a diminution of something over £1,000, arising from the fact that in the course of the preceding year we realised the bonds of a certain company on which was paid 4 per cent. interest until we took them over and converted them into money. That affected the interest. The drawings on our bankers have been a little more than they were last year, and the interest account has been turned slightly against us. Another item which we deal with as income represents stock on hand. That has been explained to you a great many times, so that it is familiar to all those who attend our meetings and those who read our proceedings. We are bound in the very nature of our business to keep a large amount of money locked up in stock. There are one or two great types of lamps—16 c.p. lamps—and small ones of other types, which are themselves subdivided into others of more or less power, and this circumstance involves this, that in order to meet the necessities of a great many of our customers and their varying requirements, we are obliged to keep a large supply of lamps on hand ready to meet any call that may be made upon us. June and July are the slackest months as regards electric lighting, but we must make sufficient provision now for the darker days, and not postpone the manufacture of the lamps until they are absolutely wanted. You will see that the stock last year was £56,266, and this year it is £59,308, which is a large amount of money to have locked up in the business. I must here qualify myself by saying that a considerable portion of the amount is not for lamps at all, but for platinum. In face of the possibility of a great rise in the price of the metal, we had to secure a large quantity of it at prices which were subsequently greatly exceeded in the market. We have now £15,000 worth of platinum in stock. The rest of the figure is made up of lamps and other manufacturing material, which must be kept in stock from time to time. Turning to the opposite side of the account, you will see what the cost of production has been. Dealing with the stock in hand on July 1st, you will find that we have increased it by £3,042. Wages, purchases, &c., amount to £56,362 19s. 6d., which represents the manufacturing cost at the factory. Wages is one of the things that do not diminish. Purchases mean material for the lamp itself, which is formed of glass, platinum, carbons, &c. Then comes salaries, Directors' remuneration, rent, office expenses, insurance, income-tax, general and law charges, £15,270. 6s. 7d. Then depreciation on plant, &c., written down as you see to the extent of £2,160. 18s. 10d., which we consider a safe quantity, being £300 over that of last year. Then the balance is £72,905, as against £61,115. That is the result of the trading for the year. I do not know whether you will consider it a satisfactory result. We think it is. We think that £11,800 more profit for the year is rather a good indication of the value of the business. When you see that the output leaves such a considerable profit as £73,000, it is not a bad business, enabling us, as it does, to recommend you to pay 7 per cent., which you are entitled to in preference to the deferred shareholders. But we must not give rise to any illusions, nor is it desirable that the outside world should believe that 17 per cent. is the normal condition of this Company. It may be just as well to know that in 1884 we paid nothing, in 1885 we paid nothing, in 1886 we paid nothing, in 1887 nothing, and in 1888 we paid nil. It was only the confidence which the Directors had in the soundness of the thing, and your confidence in the Directors, which carried them through the difficulties of those years when there was nothing to divide. That confidence has been justified by the results. Once the patent rights were settled, once the Company got upon its legs it began to pay. In 1889 for the first time we found it prudent to pay a dividend, and we paid 10 per cent., in 1890 we paid 15 per cent., and now we propose to pay 17 per cent. As that seems a large amount I daresay it will excite the cupidity of certain people, but if you will divide 42 with what we have divided with your sanction, it comes to the modest £5. 5s. per cent. per annum—not too great a reward for an enterprise of this kind. That is the outcrop of that part of the business. On the other side of the account, the balance-sheet—I do not know if it is worth while going through that. Perhaps I had better. On the debtor side you will see that the share capital remains practically intact. I mean it is not altered, there being the same number of £5 shares fully paid up and allotted to the Edison Electric Light Company (Limited). There is the same number of shares to the Swan United Electric Light Company (Limited)—the same number of "A" £5 shares, with £3 paid up, and the same number of "B" £5 fully paid up; so that our capital is £471,298. You see that, as far as the first of these are concerned, they are entitled to a 7 per cent. cumulative dividend in preference to the ordinary—not only to 7 per cent., but, in respect of the years during which you got no dividends. The first item which admits of comparison is the sundry credit balances. You owed last year £26,257, and this year £14,706. Coming to the reserve fund, we have been able to bring it up to £12,689 from £4,595, at which it stood last year. Then comes the profit and loss account as per appropriation, £69,479. When we come to appropriation we do not divide close up. We thought it prudent, after providing 7 per cent. on the current year, to complete the payment of arrears in respect of the cumulative preferential dividend owing in respect of the year ended June 30, 1885, at the rate of 3 per cent., and to pay 7 per cent. on the arrears of the cumulative preferential dividend for the year ending June 30, 1886. I have told you that in the years 1884, 1885, 1886, 1887, and 1888 there was nothing paid. We have squared it down, year by year, until we have now got 1886 balanced, and we have got 1887 and 1888 still remaining as a charge on the future, in respect to which you have had no dividend. Coming to the other side of the account, by cost of patents, goodwill, preliminary outlay, loss on working, &c., as per last balance-sheet, the further expenditure there has reference to payment for patents and legal expenses connected with the founding of the Company and its development. Against that we write off, from time to time, the amounts realised by plant, forming part of the original foundation price, but which, either from being out of date or being superfluous, we carried to the credit account, and we deduct the loss on realisation of original dynamo account £3,425, and that brings the amount down to £234,638. The amount of "B" shares of this Company issued as *per contra* is £117,820, the Manchester Edison Swan Company, Limited, 100,000 "B" shares at nominal cost. That is a deferred interst we have got in the future of that Company. Whether it will be worth that or not time only can reveal. I trust the £117,820 will bring to the owners of the "B" shares in this concern, sooner or later, something which will be a useful asset; they are entitled to one-fourth of the balance of the profits of the Company after a preferential cumulative dividend of 7 per cent. has been paid to the holders of the "A" or ordinary shares, and I hope that our profits are not going to diminish when the arrears are paid off. I think they will very likely go on. Then you come to freehold property, £45,012; plant and stock, £83,188; the fact being that during the year, in anticipation of and in order to meet the current pressure, we have been obliged at the factory to spend a considerable sum in putting up new glass blowing works. This is all under the pressure of a growing business. The money you see represented there is £45,000. We

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bought the property originally very cheap, and I have no hesitation in saying that if that property were valued to-day for the purposes of a well-established going concern, it is worth a vast deal more than £45,000. If we had to buy land and bu ld factories, it could not be done for the money. Fortunately we found ample land, with a structure upon it. The people who put it up had made an enormous loss, and we bought it cheap. It is as good for our purpose as if we had put it up specially. Debtors stand at £34,859, as against £15,203. Considering that the debtors are all good, and that the money owing to us is about double what we owe, that is a satisfactory state of things Investment in Consols at cost is £20,000, and cash at bankers £8,051. That is the end of that part of the business. Now, coming to the appropriation of this £73,000, the profit and loss as per appropriation account is £69,479. There is one item I wish to call your attention to. Amongst other things we took over originally was a quantity of machinery, installations, and all sorts of things—the fruit of the want of knowledge of the two original companies, the Edison Company and the Swan Company. They made a lot of bad bargains. They bought a lot of stuff which has turned out to be effete—dynamos and things of that sort, and some installations founded on the theory that the rental of light was a very profitable thing. The theory was a very good one, but the practice was very bad, and, instead of being profitable, it was found to be exceedingly ruinous in cost. All this is a thrice-told tale. But men are such babies that they hesitate to realise at a loss at the right moment. We realised at a loss, and got rid of all these things on the best terms he could, and this is one loss—the very last. We had a lot of dynamos which were quite useless to us, but we managed to sell them in Italy, and we got rid of them the other day. A dividend of 7 per cent. for the year works out to something less than £25,000 ; then there is the payment of the balance of cumulative preferential dividend, at the rate of 3 per cent., £10,604, and payment of cumulative preferential dividend on the "A" shares at the rate of 7 per cent., £24,743. We thought that was going far enough, and we have carried the rest to reserve, and I hope you will approve that recommendation of the Board, because it is in your hands, not ours. These are the bare bones of the account. There is one thing I should just like to call your attention to. Of course, we are face to face now with this —there is so much capital ; a very large sum of money, and the patents are running out in two years and a few months. One looks with some anxiety on the past of a concern of this kind—the cost of patents, goodwill, the loss on working, and so on. That pulls down to £234,638. 17s. 7d. That is a considerable amount, but I do not think it is one that need alarm you. It is the cost of founding this business and carrying it through to that moment when we shall be in competition with the whole of the world. It is best to say it ; it would be silly if we did not say it, but we have the most perfect lamp factory in this, or, probably, any country of the world. I think ours has the best reputation of any lamp in any country. By the great perseverance and exceeding skill on the part of your technical advisers, and by the great zeal and energy on the part of the officials, you have had established a going concern on a very large scale, but this, as other large businesses, cannot be conducted without the investment of a great deal of money, and, therefore, those people who are going to compete with us will compete with us thoroughly equipped, and with a reputation thoroughly established. We shall have to take our chance for the future ; but it will come to this, I suppose, that although during a certain period, when enormous risks had to be run, when the public had to be educated in these things, and when it was a question whether success would attend you or not, you had a protected period, and rightly so, and there are blatant people who cry out about monopoly, and who will be prepared to say, though you are able to make a better lamp than you are doing, or at all events as good a one, at a price below any small maker, or any considerable maker, still you must take your chance with the public. If, however, we can double or treble our present sales in the two years and the few months yet remaining of our patent rights, and, when the time comes, if we can afford to take a very modest profit on our enormous ouput, we shall be in a comparatively strong position. Major Page calls my attention to the fact that we are not dependent on the lamp patents as covering only a certain time ; but we have patents in respect of very important parts of the lamp, sockets, and fittings, which extend a long time beyond the lamp patents, and from which we hope in the future to derive a very considerable income in the shape of royalties, and which may be very valuable. This, then, is the result of the working of this concern. We are not only now paying this assured dividend with the arrears, which will possibly be continued in the future for some considerable time, but in the interim, from 1884 to 1891, we have written down £301,000 to £234,638, and everybody knows that so much less to pay is a thing that you can contemplate with equanimity. That has been done out of the profits of the undertaking ; some of it out of the sales, superfluous plant and property, but most of it out of the profits of the undertaking. We kept writing down and writing down before we paid any dividend at all. The loss of the business had to be compensated before we began to distribute a dividend. It was not because there was not a balance to do it, but it was because we had large arrears in the shape of bad investments to write down. Therefore, you are in this happy position, that the original claim to be liquidated has been reduced by £66,000. One of the interests of a company like this is that we should be very cautious about our details. It is already quite bad enough in a joint-stock company, which is obliged to submit in black and white, from time to time, a certain number of details of its business. Prosperous people who manage their own affairs keep such things to themselves, and we are obliged to keep as much as is necessary to ourselves, because many people would like to know where we get our profit from, and so on. They may induct as much as they like ; but inductions are not as good as positive information. You must be good enough to believe there are reasons for dealing in generalities. Therefore, roundly speaking, your position is this : that your improved investment is put down at something like £125,000. I think that fact, coupled with the dividend you are getting now, is not altogether discouraging. With these remarks, subject to my readiness to answer any question, I move—

"That the report and the accounts for the year ended June 30th be received and adopted."

Mr. F. R. LEYLAND seconded the motion.

Mr. PELL asked whether all the lamps made by the Company were marked "Edison and Swan," as he had seen a great many not bearing any mark at all.

The CHAIRMAN replied that the bulk of the lamps were made by themselves. They had a few from Edison, which were marked "Edison," but their own was much the largest number. If the hon. proprietor saw any lamp not marked, perhaps he would kindly intimate it at the office.

A SHAREHOLDER asked how many lamps were represented by the item in the profit and loss account by sale of lamps, &c., £143,229.

The CHAIRMAN said it was a piece of information that he could not give, inasmuch as it would be very useful to their opponents.

A SHAREHOLDER wished to ask a question about the unnegotiability of the shares. He was a fortunate holder of the Edison and Swan shares, which he had no difficulty in getting, but he had the greatest difficulty in dealing with them. Some people might want to administer their affairs, and, in the face of that, he wished to ask whether they could not get a quotation for these shares.

The CHAIRMAN said that they had been advised by a very eminent broker, who told them that there was a great difficulty about this question. He thought that it, to a great extent, arose from the fact of the shares of the Edison part of the undertaking having been brought into the amalgamation under very different conditions from those of the Swan. The latter had no assets in the shape of foreign patents. In order to work those patents they had kept up their separate existence, and the difficulty was this, that they held the major part of the shares in this Company. They had been talking over the matter for years to see if they could not come to some arrangement by which the Swan Company would be absorbed by this Company, but they had not been able to do it. He quite appreciated the disadvantage there was about it. On the other hand, the Swan people might have some views about the advantages of keeping it where it was. At the same time, one could not conceive that it might not be done whenever it appeared opportune or wise to do it.

A SHAREHOLDER asked whether they were in the same position in respect of holders as of lamps.

The CHAIRMAN replied in the affirmative, adding that the difference between the holder of the lamp patent and the other was this, that the Company had reserved the absolute right to manufacture and sell the lamps, but they had licensed a great many first-class firms to be manufacturers of these holders and sockets for incandescent electric lamps under the Company's patents.

Another SHAREHOLDER advocated as a measure of safety the continuance of the investment in consols, and thought they ought to be grateful to the Directors and management generally for the masterly way in which the accounts had been presented.

The CHAIRMAN said that the previous speaker might rely on his suggestion receiving the attention of the Board. They had gone on the principle of making things safe. He could remember the time when, at meetings of that kind, things were not so pleasant as they were. Of course the shareholders knew that some of the Directors were interested very largely, financially, in this undertaking. Others were not so largely interested, but they had the same disposition to safeguard the interests of the proprietors. He then moved :—

"That a dividend at the rate of 7 per cent. per annum be, and is hereby, declared on the 'A' shares of the Company for the half-year ending June 30, 1891 (making 7 per cent. for the year), and of 3 per cent. in completion of payment of arrears of Cumulative Preference Dividend for the year ending June 30, 1885, and of 7 per cent. in respect of arrears of Cumulative Preference Dividend for the year ending June 30, 1886 ; all to be distributed in accordance with the provisions of clause 87 of the Articles of Association."

This dividend works out to the following amount per share :—On the 89,261 ordinary shares, 8/3$\frac{27}{32}$ per share ; on the 5,000 fully paid, allotted to the Edison Electric Light Company (Limited), 13/10$\frac{7}{8}$ per share : on the 12,139 fully paid, allotted to the Swan United Electric Light Company (Limited) 11/8$\frac{3}{4}$ per share.

The motion, which was seconded by Mr. LEYLAND, was carried *nem. con.*

Mr. LEYLAND then assumed the chair and proposed the re-election of Mr. Forbes to his seat at the Board, paying a warm tribute to that gentleman for the ability and interest he had shown in promoting the interests of the Company.

Viscount ANSON seconded the resolution, which was cordially agreed to.

Mr. FORBES resumed the chair and thanked the meeting for his re-election. In common with his colleagues, he said, he would always do his best to protect the interests of the Company and make it a valuable property for the future. He then proposed the re-election of Mr. Leyland to his seat at the Board, paying a similar compliment to that gentleman by saying that it was owing to his great experience and knowledge, backed by the assistance he received from his colleagues, that the Company was rescued many a time from great peril.

Mr. ERNEST VILLIERS seconded the motion, which was carried unanimously.

Mr. LEYLAND having thanked the meeting for his re-election,

Mr. PELL proposed, and a SHAREHOLDER seconded, the re-appointment of the auditors, Messrs. Welton, Jones and Company.

The motion was agreed to unanimously.

A vote of thanks having been passed to the Chairman and Directors, the proceedings terminated.

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Globe Telegraph and Trust Company (Limited).

The following is the report of the Directors, to be presented to the eighteenth ordinary general meeting, to be held at Winchester House, Old Broad-street, London, E.C., on Tuesday, the 28th July, 1891, at 1 p.m. :—

The net revenue of the Company for the year, after deduction of expenses, amounts to £201,698. 12s. 1d., which, with the balance of £118. 18s. 6d. brought forward, makes a total of £201,817. 10s. 7d. From this amount there has been distribut the sum of £133,059. 5s. 3d. in interim dividends, leaving an available balance of £68,758. 5s. 4d.

The Directors recommend the payment of a final dividend for the year of 3s. per share on the preference shares, and of 4s. 6d. per share on the ordinary shares, making, with the former distributions, a total dividend for the year of 6 per cent., less income-tax, upon the preference, and 5¼ per cent. net upon the ordinary shares (against 5 per cent. for the preceding year), and carrying forward a balance of £1,876. 15s. 9d.

The Imperial German Government have, in virtue of their agreement entered into with the German-Norwegian Telegraph Company, taken over that Company, and will pay off the capital at par. This Company held virtually the whole of the capital, which is now being paid off. 95 per cent. of the amount has already been encashed, less exchange, and the balance, in accordance with German law, will be payable in the early part of next year. The sum repaid has been £66,956. The Directors have re-invested this capital in the following securities :—1,850 shares in the Western Union Telegraph Company, costing £31,482. 18s. 1d. ; 2,050 shares in the American Cable Company, costing £35,337. 11s. 2d. There remains a small balance still to reinvest.

In conformity with the Articles of Association the Marquis of Tweeddale and James Pender, Esq., two of the Directors, retire, and offer themselves for re-election. The auditors, Mr. John George Griffiths, F.C.A. (Messrs. Deloitte, Dever, Griffiths and Co.), and Mr. William Griffith, B.A., barrister-at-law, also retire at the meeting, and offer themselves for re-election.

Telephone Company of Austria (Limited).

The following is the Directors' report to be presented at the eighth ordinary general meeting of the Company, to be held at the offices, 53, New Broad-street, London, E.C., on Thursday, the 30th July, at four p.m. :—

The Directors have much pleasure in presenting to the shareholders their report and accounts for the year ending March 31, 1891.

There has been expended on capital account a further sum of £8,868. 7s. The gross receipts in Austria were £18,513. 14s. 0d. After providing for all expenses, including £4,418. 6s. 2d. for debenture interest and dividend on preference shares, and £3,520. 7s. 6d. for royalties and taxes to the Austrian Government, the profit on the year is £3,438. 16s. 2d., which, with the £1,047. 2s. 7d. balance from last year, gives a total of £4,485. 18s. 9d. to the credit of profit and loss account, which amount it is proposed to carry forward.

In view of the expiration in October next of some of the Company's concessions, negotiations with the Austrian Government as to the future of the Company have been in progress for a considerable time past. These negotiations are now approaching their final stage, and the result will be brought to the knowledge of the shareholders without delay. Under these circumstances your Board do not recommend at present the payment of any dividend on the ordinary shares.

The Directors have again to report a continued increase in the number of subscribers to the Company's exchanges, as shown by the following table :—

	No of subscribers.	Increase over previous 12 months.	Rental.	Increase over previous 12 months.
March 31, 1890...	2,652	..... 353	210,000fl.	..... 27,450fl.
March 31, 1891...	*3,023	..... 371	238,000fl.	..... 28,000fl.

* Exclusive of 240 "Extension" telephones, which give an additional rental of 8,210fl.

Installations in the towns are progressing at the usual rate, and, so far as the Board can judge, seem likely to continue. The calls of subscribers now average over 97,000 per week, as against 70,000 last year.

The thanks of the shareholders are again due to Dr. Eugen Weissel for his continued valuable services during the past year, and to Mr. Krause for the very satisfactory manner in which he continues to perform his duties as general manager.

Mr. Henry Grewing retires by rotation from the Board, but, being eligible, offers himself for re-election. The auditors, Messrs. Deloitte, Dever, Griffiths and Co., also retire, but, being eligible, offer themselves for re-election.

Venezuela Telephone and Electrical Appliances Company (Limited).

The following circular has been sent to the shareholders, under date 20th July, 1891 :—I beg to inform you that the half-yearly interest on the debentures of this Company, due on the 31st inst., will be paid, on presentation of the Coupons, on and after that date, either in Amsterdam or at the Consolidated Bank (Limited), London.

It may afford you satisfaction to see the following figures, which point, as you will observe, to a steady growth of the Company's business since its incorporation, and to its success in the future.

The earnings have been as follows :—

	Gross.	Nett.
To December 31, 1890	£9,028	... £3,495
For month of January, 1891	1,120	... 500
„ „ February „	1,150	... 520
„ „ March „	1,210	... 520
„ „ April „	1,250	... 540
Estimated returns for May and June (the end of the financial year), based on the April returns	2,500	... 1,080
	£16,258	.... £6,655

The proportion of working expenses to gross earnings has been abnormally large during this period, owing to the fact that the works, during the whole of the year 1890 and up to the present time, have been under reconstruction and rearrangement.

It will be seen that, after providing for the debenture interest, which amounts to £3,500 per annum, and for the administration expenses in England, there will remain a considerable balance for dividend on shares.

The subscribers during the period above referred to have increased from 1,511 in April, 1890, to 2,092 in April, 1891 (viz., 1,721 connected up and 371 in course of being connected).

It is contemplated to increase the rental for the telephones, and as subways for underground wires have now been laid on a portion of the Company's system, there is every expectation of a considerable reduction in the working expenses in the future, which, together with the growing increase in the gross earnings, should add considerably to the profits in the current year, which commenced on the 1st inst.

Crompton and Co. (Limited).

The following is the third report of the Directors, to be presented at the annual general meeting of the shareholders, at the City Terminus Hotel, Cannon Street, in the City of London, on Wednesday, the 29th July, 1891, at 2: 30 p.m. :—

The Directors beg to submit to the shareholders the third annual statement of accounts and balance sheet made up to the 31st March last.

The business of the Company continues to increase, the order book is well filled, and negotiations are on foot for several important central station contracts, in addition to those at present in hand.

The Directors have given considerable attention to improved arrangements at the Chelmsford works for increasing the output, so as to ensure punctuality in the execution of orders. The fitting up of the London works, referred to in the Chairman's speech at the general meeting last year, has also been completed. These alterations and additions have entailed a rather heavy outlay on capital account.

Mr. J. F. Albright, one of the Managing Directors, has been on an extensive tour through Canada, the United States, Australia, India, and the Cape, visiting the different agents of the Company, and making arrangements which it is hoped will lead to a considerable extension of the Company's business abroad. The date appointed for the meeting of the Shareholders has been delayed to allow for Mr. Albright's attendance, on his return to England.

The net profits of the year amount to £13,030. 14s. 7d., and, after providing for the debenture interest and other payments set out in the revenue accounts, and deducting the interim dividends already paid on both the preference and ordinary shares, there remains, with the £474. 18s. 10d. brought forward from last year, a balance available for dividend of £6,484. 18s. 10d.

The Directors propose, after setting aside a sum of £500 as a provision for doubtful debts and contingencies, to declare a dividend of 3s. 6d. per share, making 7 per cent. per annum upon the preference shares, and 5s. 6d. per share, making, with the interim dividend, a total of 8 per cent. per annum upon the ordinary shares, carrying the balance forward.

Sir Charles Grant has retired from the Board, and the Directors have elected Mr. H. H. J. W. Drummond and Viscount Emlyn to fill this vacancy and that caused by the death of Viscount Torrington, mentioned last year. In accordance with the Articles of Association, Mr. B. Gibson retires from the Board of Directors by rotation, but offers himself for re-election. The auditors, Messrs. J. H. Duncan and Co., also offer themselves for re-election.

NEW COMPANIES REGISTERED.

JOSEPH EVANS AND CO. (LIMITED).—Registered with a capital of £10,000, in £5 shares. Object: To acquire the undertaking of Joseph Evans, of 118, Charles Henry-street, Birmingham, and to carry on thereat the business of tube manufacturers and manufacturers of and dealers in every variety of metal work.

ITALIAN ELECTRICAL LIGHT AND POWER COMPANY (LIMITED).—Registered by A. W. Rixon, 10, Austinfriars, E.C., with a capital of £60,000, in £4 shares. Object: to carry on every description of business connected with the generation, supply, and use of electricity for the purposes of light, power, or otherwise. The first subscribers are :—G. Taddei, 83, Via Arenula, Rome ; P. Alessandri, 92, Via dei Farnesi, Rome ; J. Reid, 101, Leadenhall-street, London ; C. E. Stuart, 4, Aberdeen-terrace, Highbury ; A. P. Windridge, 344, Stanstead-road, Catford ; T. Wholey, 7, Storey's-gate, S.W. ; J. Carr, 35, Paget-road, Stoke Newington. There shall not be less than three nor more than eight Directors ; the first are

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to be determined in general meeting. Qualification, 25 shares. Remuneration, £50 each per annum, the same to be divisible as they shall think fit.

PATENT ROYALTIES COMPANY (LIMITED).—Registered with a capital of £10,000 in £1 shares. Objects (*inter alia*): To carry on the business of electrical engineers, and makers of electrical apparatus, machines, and instruments. The office is at 8, Old Jewry, London, E.C.

CITY NOTES, &c.

ANGLO-AMERICAN TELEGRAPH COMPANY.—At a meeting of the Board of Directors of this Company, on Friday last, it was resolved to declare an interim dividend for the quarter ended June 30, 1891, of 12s. per cent. on the ordinary stock, and £1. 4s. per cent. on the preferred stock, less income-tax, payable on August 1st to the stockholders registered on the books of the Company on the 14th July last.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).—Notice is given that the coupons of this Company's Five per Cent. Debentures (1884 issue), due on the 31st inst., will be paid on and after that date at the Alliance Bank, Bartholomew-lane, London, E.C., where they must be left three clear days for examination.

CITY AND SOUTH LONDON RAILWAY COMPANY.—The traffic receipts of this Company for the past week amounted to £689.

MANGANESE BRONZE AND BRASS COMPANY (LIMITED).—A final dividend of 10s. per share, making 18s. per share for the year ended the 30th ult., is recommended by the Directors, leaving £1,805 to be carried forward.

SPANISH NATIONAL SUBMARINE TELEGRAPH COMPANY (LIMITED).—This Company announce an interim dividend of 2s. a share, payable on the 31st inst.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The receipts of this Company for the half-month to July 15th amounted to £1,981, as compared with £2,858 for the corresponding period last year.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, July 15.		Price Wednesday, July 22.		Rate per Cent. Yielded.	Dividend Due.	Business done during Week ending July 22.	
										Highest.	Lowest.
			TELEGRAPHS.					£ s. d.			
£1,300,980	Stock	12/0	Anglo-American	45½	46½	44½	45½	6 5 11	Jan., Apr., July, Oct.	..	..
£2,849,510	Stock	21/0	Do. Preferred	84	85	83½	84½	6 14 11	" "	84½	83⅜
£2,849,510	Stock	..	Do. Deferred	10½	11	9⅝	10⅛	..	..	11	..
£250,000	100	4%	African Direct, Telegraph 4% Debentures	98	101	98	101	3 19 3	January and July	..	..
130,000	£10	5/0	Brazilian Submarine	11½	12	11½	12	7 1 8	Mar., June, Oct., Dec.	11⅛	11⅛
£69,200	£100	5%	Do. 5 per Cent. Bonds	101	104	101	104	4 16 2	January and July	103½	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103	107	103	107	4 13 6	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	103	107	103	107	6 6 2	April and October	..	..
16,000	10	8/0	Cuba Submarine	10½	11½	10½	11½	6 19 2	February and August	..	..
6,000	10	10%	Do. Preference 10%	17	18	17	18	5 11 1	" "	17½	..
12,931	5	3⅝	Direct Spanish (£4 paid)	3½	4	3½	4	7 0 0	April and October	..	..
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	10½	10⅝	10½	10⅝	6 10 3	Jan., Apr., July, Oct.	10⅝	10⅜
400,000	10	2/6	Eastern	14⅛	15	14⅛	15⅛	4 5 11	" "	15	14⅞
70,000	10	6%	Do. 6 per Cent. Preference	15	15½	15	15½	3 17 6	" "	15⅜	..
£1,200,000	Stock	6%	Do. 4 per Cent. Mort. Debenture Stock	106	109	106	109	3 13 5	May and November	108½	106½
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 10 11	February & August	..	..
250,000	10	2/6	Eastern Extension	14⅞	15⅛	14⅞	15⅛	4 12 7	Jan., Apr., July, Oct.	15⅛	14⅞
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock	105	108	105	108	3 14 1	February & August	108	..
£85,800	100	5%	Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	101	104	101	104	4 16 2	January and July	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	101	104	101	104	4 14 4	" "	..	..
180,227	10	2/6	Globe Telegraph and Trust	9⅜	9⅞	9⅜	9⅞	5 3 10	Jan., Apr., July, Oct.	9⅞	9⅞
180,042	10	6%	Do. 6 per Cent. Preference	15	15½	15	15½	3 18 8	" "	15½	14⅞
150,000	10	5/0	Great Northern	18½	18⅝	18½	18⅝	4 10 8	Jan., April, and July	18⅝	18½
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105	108	105	108	4 12 7	March & September	..	..
17,000	25	37/6	Indo-European	39	41	39	41	4 11 3	May and November	40⅜	40
88,348	10	5/0	London latino-Brazilian	6½	7⅛	6⅜	7⅛	6 0 0	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106	109	106	109	5 10 1	March & September	..	..
8,000	8	4/0	Reuter's	8	8½	8	8⅜	4 14 1	April and October	..	..
3,381	£100 Cert.	£1	Submarine Cables Trust 6%	115	120	115	120	5 0 0	" "	115½	..
15,609	10	6/0	West African Telegraph	8	9	8	9	5 11 1	January and July	..	..
£281,400	100	5%	Do. 5 per Cent. Debentures	95	98	96	99	5 1 0	March & September	97	..
30,000	10	2/0	West Coast of America	3	4	3	4	..	January and July	..	..
£150,000	100	8%	Do. Debentures 8% 1902	97	102	97	102	7 16 10	June and December	..	..
88,321	10	9d.	West India and Panama	2⅛	2⅜	2	2⅛	..	..	2⅛	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10	10½	10	10½	5 14 3	May and November	10⅜	10⅛
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9	10	9	10	6 0 0	" "	..	..
61,683	15	9/0	Western and Brazilian	11	11½	11	11⅛	7 10 11	" "	11⅛	..
30,364	7½	1/6	Do 5 per Cent. Cumulative Preferred	6½	7	6⅜	7	5 7 8	—	..	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	4⅜	5	4⅛	4⅜	..	..	4⅛	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	104	107	104	107	5 12 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103	106	103	106	5 13 2	" "	105½	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117	122	117	122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	100	104	101	105	5 14 3	March & September	104½	..
			TELEPHONES.								
224,850	14/0	0/4½	Consolidated Telephone Const. & Maintenance	1⅞	1⅞	1⅞	1⅞	7 9 4	May and November	..	..
220,000	£1	4/6	Oriental (11s. paid)	1⅝	1⅝	1⅝	1⅝	6 8 11	Yearly	..	..
438,984	5	3/6	National	4½	5⅛	4⅜	4⅞	6 3 1	June and December	5	4⅞
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	13	14	12⅝	13⅝	4 8 11	" "	13⅛	..
15,000	10	6%	Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd)	12½	13	12⅝	13	8 14 1	" "	12⅛	..
350,000	£10	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd)	104	105	105	107	4 4 1	.. ..	106⅛	105⅛
58,000	5	1/0	United River Plate	2	3⅛	2	3	..	January and July	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 8	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
1,000	£50	..	City of London Electric Lighting Shares (£50 pd)	60	62	60	62	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	4½	5	4½	5	..	..	..	..
5,322	£5	..	House to House Electric	4⅞	5⅛	4⅞	5⅛	..	..	..	..
30,000	£5	..	Liverpool Electric Supply (£3 paid)	2⅜	2⅝	2⅜	2⅝	3 13 1	..	..	..
111,000	5	..	London Electric Supply	1⅞	2	1⅞	2	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	9½	10½	9⅜	10⅛	4 7 7	..	..	..
7,730	£5	..	St. James' and Pall Mall	6⅞	7½	6⅞	7½	—	..	7⅛	6⅞
..	..	7%	Do. 7% Preference	3½	3⅝	3½	3⅝	—	..	3⅛	3½
42,853	5	..	Westminster Electric Supply (£5 paid)	4⅜	5⅛	4⅜	5⅛	..	..	5⅛	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978	3	..	Brush Electrical Engineering	2⅝	2⅞	2⅝	2⅞	..	..	2⅝	2⅞
69,996	2	6%	Do. 6 per Cent. Preference	1⅞	2	1⅞	2	6 0 0	June and December	1⅞	1⅞
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	4	5	4	5	7 0 0	January and July	..	..
17,130	5	..	Edison and Swan United	..	..	..	..	..	—	..	..
45,000	10	6%	Electric Construction	3	4	2½	3½	..	—	..	..
70,000	2	10/0	Elmore's Patent Copper Depositing	3½	4	3¼	3⅜	..	—	3⅛	2⅜
20,000	5	..	Fowler-Waring Cables (£4 paid)	2	3	2	3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works xd	19⅜	20⅜	18½	19½	5 2 7	February & August	19½	19
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	105	103	105	4 5 9	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	7⅛	8½	7⅛	8½	11 15 3	..	..	..
11,334	£10	5/0	Do. Preference	9½	9⅝	9½	9⅝	8 4 1	..	..	..
78,949	5	2 1½	Swan United (£3. 10s. paid)	4⅜	5	4⅜	5	6 19 10	May and November	4⅜	4⅝
37,250	12	12/0	Telegraph Construction and Maintenance xd	44	46	44	46	5 4 9	March and July	45½	44⅜
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101	104	101	104	4 16 2	January and July	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£3 paid)	2⅛	2⅜	2⅛	2⅜	..	..	..	..
..	£5	..	Do. Preference (fully paid)	3⅛	4⅛	3⅜	4⅛	—	..	..	..
			RAILWAYS.								
50,000	£10	..	City and South London Railway	4	5	5	5	—	—	—	..

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THE ELECTRICIAN:

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NOTES.

A large and varied assortment of reasons can readily be marshalled up to account for the rapid development of electric traction in the United States, and its snail-like progress in the United Kingdom. If a reproduction of the results obtained with the electric cars on the Boston West End Railway could be guaranteed on this side of the Atlantic—and we know of no insuperable obstacle—even the most cautious of tramway directors might be induced to emerge from the "experimental stage." In Boston, according to our New York correspondent, electric traction costs nearly 10 per cent. less than horse traction per mile run, and its net earnings amount to over 77 per cent. more. Meanwhile, we in this country are still hammering away at battery traction, pending the advent of the perfect closed conduit.

The guarantee and maintenance of storage batteries, to which we referred last week, is not offered, as we stated, by the Electric Construction Corporation, but by the Foreign and Colonial Electrical Power Storage Company. It is really very difficult to bear in mind not only the new names under which old companies combine, especially when they are so very similar, but to remember who belongs to which. The Electric Construction Company was formed two years ago as the fusion of the well-known firm of Elwell-Parker with the Electrical Power Storage Company, the Foreign and Colonial E.P.S. Company being left out in the cold. But it seems that storage batteries and alternating dynamos do not run happily in parallel, and not only has the Elwell-Parker battery been given up, but the whole of the battery business is going to the Foreign and Colonial Company. This practically means that an electrolytic decomposition is about to take place; but the E.P.S. element cannot at present assume its old title, and the Foreign and Colonial branch has nominally come to life again to do the business at the old address and works of the E.P.S. The Corporation, would do well to resume the more easily remembered, and we may say more celebrated, name of Elwell-Parker.

While we strongly sympathise with Prof. Perry in his endeavour to simplify the confused and annoying systems of electromagnetic units, and while we feel sure that some simplification would be warmly welcomed by engineers, we regret that his suggestions were not made eight or ten years ago, when there would have been far less difficulty in effectually introducing them. We would gladly assist the matter by publishing the views of our readers, and hope that sufficiently convincing argument may be raised to overthrow the opposition which is sure to come from educational quarters. Electrical engineering has been regarded by certain advocates of the decimal system as a vulnerable point in the engineering profession a young and tender part, into which the thin end of the metric wedge may be thrust. Amid all the difficulties of mathematical theories the foreign flavour of the C.-G.-S. system is only a slight inconvenience to a student. He accepts the volt and ampere as a matter of course, but behind the watt lurks the erg and the dyne; he is taught to sneer at the foot pound, and to regard the horse-power as an antiquated convention. If he lingers long in the laboratory, and does not yearn for the vice and a job that he can hit with a hammer, and hit hard, he is likely to end by designing dynamos in centimetres, and to grumble at having to translate everything into the nearest inch measurement, with the result that the drawings bristle with thirty seconds, if not sixty fourths.

The C.-G.-S. system, as set forth in Everett's Units and Physical Constants, goes on merrily through mechanics, hydrostatics, strains and stresses, astronomy, sound, and light. It begins to falter in Chap. IX., on heat, when t has to appear, and again when Q turns up in the section on thermal conductivity, the dimensions of which are $k = Q/v_2 - v_1 \cdot x/At$, and this is after all only M/LT, or perhaps L^2/T; and when Joule's equivalent is arrived at, the student feels that the C.-G.-S. system is becoming strained. The next chapter on magnetism reveals unmistakably that whatever may have gone before, the arbitrary choice of units leads to very serious complications, and perhaps the one satisfactory point is, that the two conflicting systems of measurement have a ratio which appears to have a real existence as a "definite concrete velocity." The difficulty is, however, not entirely due to an attempt to force the C.-G.-S. system to adapt itself to quantities which will not fit it, but is brought about by the perfectly unwarrantable assumption that the specific inductive capacity of air, or of ether in air, is 1, and that at the same time the magnetic permeability, or μ, of air is also 1. Both these conventions cannot be true, and, as Dr. Oliver Lodge has pointed out, no one has the least right to suppose either true; but yet on these is built the purely artificial system of volts, ohms, farads, and the like. Conventions of this sort, especially when they lead to difficulties which obscure even simple calculations, are particularly obnoxious to the busy engineer. Prof. Perry has as much right to say that the μ of air is $17\frac{1}{2}$ as anyone else has to say that it is 1. But,

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in suggesting that it shall be $4\pi \times 10^{-9}$, he removes at one stroke practically the whole difficulty of applying the C.-G.-S. system to practical engineering; and we do not hesitate for a moment to go further with him, and hope that, even yet, before it is too late, engineers will adopt the last four rules in his suggested system, and, for workshop and general engineering purposes, use inches, and thereby not only save themselves a great deal of extra work and time, but permit to enter the field that large contingent of engineers who are at present kept out by the serious complexity of the method of calculation.

Our excellent contemporary, the *Journal of Gas Lighting*, generally has something readable in its Electric Lighting Memoranda, and the conclusions at which the writer arrives are really creditable, considering the sources of information on which they appear to be based. One or two further hints would at times set him on the right track, and as the reasoning is always honest, a good deal more valuable information on electrical matters might be set before gas engineers than is done at present. This week's issue discusses the question, "When does it pay best to renew the lamps, knowing their price, efficiency, and the cost of current in every case?" "Electricians," says our contemporary, "connected with central stations are very shy of the subject," forgetting that the last batch of statistics was presented by Mr. F. Bailey. "It is marvellous," it continues, "that nobody seems willing to confess to being in possession of reliable data, obtained from experience, of what incandescent lighting of a definite quality actually costs in the United Kingdom, including everything." But the reason is very simple; we are waiting until competition in lamp manufacture begins. Until then, no arguments can possibly induce the present makers to divulge the figures which they alone can accurately give. It is not worth the while of any consumer to make not only elaborate records of life, but experiments on the relation between life and efficiency. Fierce competition may, however, be expected to bring these to light. Meanwhile, we run lamps at 4 watts to the candle because the makers recommend it, and no one suspects them of endeavouring to increase their trade by suggesting that their lamps should be over-run.

The *Journal of Gas Lighting* assumes that it will pay to throw a lamp away when it begins to "exhibit that lively appearance of a newly-blown-out wooden match," and it is quite possible that under some circumstances this might be the case, but though a certain make of lamp used to run down very much after 600 or 800 hours, the general experience with Edison-Swan lamps is that when they have run about 1,000 hours on the voltage for which they are marked, the filament suddenly gives way. In an article which will be found in another column, it is suggested that, at any rate in Paris, a lamp taking 3 watts per candle with a life of 500 hours, would be a great desideratum. A little arithmetic will show that with an eight candle lamp, taking (at 4 watts per candle) 32 watts, the energy for 1,000 hours at 7d. per unit comes to 18s. 8d., and with 3s. 9d. for the lamp, the total is £1. 2s. 5d. With 3 watts per candle the energy would come to 14s., and the cost of two lamps being added, the total is £1. 1s. 6d. In London, therefore, the difference is only 11d., and being spread over about two years, is not worth troubling about. To make the total cost in the two cases exactly equal the 3-watt lamps should have a life of about 467 hours. The American statistics recently published are of no use whatever to us, as, for the next two years or so, we are concerned only with one kind of lamp. It is possible that with cheap lamps it will be worth while in many cases to run them up bright, but the greater frequency of the sudden extinctions might become troublesome. Phenomenal lives are often recorded, but against these must be set the not uncommon cases of failure after a few hours.

Dover.—The tender of the Brush Company for the supply of the electric light is being discussed by the Town Council.

Trunk Wire Telephony in Germany.—The telephone trunk line connecting Stuttgart, Ulm, Augsburg, and Münich was opened to the public on July 1st, and was largely patronised.

Central London Railway Bill.—In the House of Commons, on Tuesday night, the Lords' Amendments to the Central London Railway Bill were considered and agreed to, and the Bill ordered for third reading.

Institution of Mechanical Engineers.—Among the works inspected by this Institution during its visit to Liverpool was the Liverpool Electric Supply Company's Works. This Company has now three central stations in operation.

The Utilisation of Water-power.—According to the *Elektrotechnischer Anzeiger*, the right to use a 60 H.P. water-fall, has been purchased by the town of Erding, in Bavaria, with the object of running a central station for electric lighting.

Glasgow.—Wednesday of this week was the last day for receiving applications for the new post of electric lighting engineer to the Corporation of Glasgow; and on that day there had been received somewhere about 50 such applications.

Stoke-on-Trent.—At the last meeting of the Town Council the Town Clerk was instructed to take steps to promote a Bill in Parliament enabling the Corporation to erect new gas works, and to supply electrical energy for public or private purposes.

The Late Mr. Willoughby Smith.—With reference to our note of last week regarding the funeral of Mr. Willoughby Smith, we are asked to mention that, in addition to the many friends named, the funeral was attended by over 100 of the staff and workmen of the firm of Messrs. Elliott Brothers.

Rule of Thumb.—A foreign observer defines the rule of thumb thus:—"You lift up a foot rule, place your thumb at zero, and move it along inch by inch until you think it is time to stop, a process known as 'thinking what to do' by some of the members of the engineering trade." It is a dangerous practice for amateurs.

The "Amber."—The Committee of the Royal Humane Society have conferred the medal for saving life on Mr. Robert Greey, commander of the Eastern Telegraph Company's steamship "Amber," for, "by presence of mind and good organisation and arrangements at the time, being the means of saving a number of lives on the occasion of the wreck of the 'Utopia.'"

Dublin.—Within the next four or five months some of the chief streets of Dublin are expected to be illuminated by electricity. The foundations of the central station buildings have been, by a piece of good luck, most admirably chosen, being on solid rock. The first streets to be lit up will be O'Connell-street, Westmoreland-street, College-green, Grafton-street, Dame-street, Parliament-street, Capel-street, Mary-street, Henry-street, College-street, and D'Olier-street.

Chicago Exhibition.—On Monday the Lord Mayor entertained the Chicago Commissioners at luncheon at the Mansion House.—On Tuesday the Commissioners waited upon Lord Cross, Secretary of State for India, and expressed their urgent

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desire that the Indian Empire should be adequately represented. Lord Cross promised to communicate with the Viceroy on the subject. In the afternoon the Commissioners entertained a distinguished company at luncheon at the Savoy Hotel.

An Aluminium Steamboat.—An aluminium steamboat is now running on the Lake of Zürich. The boat weighs only about half a ton, viz., about half the weight of an ordinary boat of the same size. It was built at the works of Messrs. Escher Wyss and Co., of Zürich, the metal having been furnished by the Aluminium Works of Schaffhausen. The boat carries eight persons, and, with a 2 H.P. petroleum engine, easily makes six miles an hour.

York.—At the last meeting of the Streets and Buildings Committee of the City Council a report was received from Mr. Crompton, electrical adviser to the Corporation, relative to the projected introduction of the electric light. After the report had been fully discussed, the Electric Lighting Sub-Committee were instructed to visit Bradford and Newcastle, with the object of informing themselves as to the relative advantages of the high and low tension systems.

Bristol.—Last week the Electric Lighting Committee of the Town Council held a meeting for the purpose of receiving tenders for the preliminary works in connection with the electric lighting central station, but found that they had been practically boycotted by the trade. Instead of offers to undertake the work, they received a long list of objections to the provisions contained in the contract. The Committee appointed two members to confer with two representatives of the Master Builders' Association.

Thunderstorms.—A severe thunderstorm visited the south of England on Monday last. At the village of Lacy Green, near Princes Risborough, Bucks, while a flower show was in full progress, a heavy thunderstorm came on. Nine men were under a tree watching the operations of drawing a hive, when a flash of lightning struck the tree. Three of the men were killed, and three others were greatly injured.—At Lewes the race stand telegraph office was struck by lightning, set on fire, and destroyed.

Street Transformers.—The London Electric Supply Corporation recently gave notice to the London County Council of their intention to construct a street box in Coventry-street. The Company proposed to construct a pit, 5ft. square and 6ft. deep, with a cover in the footway about 2½ft. square, and to place two transformers therein, a cellar which had hitherto been used for this purpose being no longer available. The Highways Committee were of an opinion that such an interference with the public thoroughfares should not be sanctioned, and recommended the Council not to approve of the works.

Electric Haulage in Mines.—An electric haulage plant put in by Messrs. Crompton and Co. was inaugurated with some ceremony last week at Abercanaid, South Wales. The plant consists of compound condensing Marshall engine, and a 100 H.P., 500 volt, Crompton compound dynamo. From the generator sheathed cables are led under the road down the pit shaft, to a 50 H.P. motor situated about 800 yards from the pit bottom. This motor is series-wound, and runs at 800 revolutions. The power is transmitted from the motor by ropes to an intermediate shaft, to which the drums are geared by pinion wheels.

Engineering Department, Cambridge University.—Mr. W. E. Dalby, B.Sc. (Lond.), and Mr. C. G. Lamb, B.Sc. (Lond.), have been appointed Demonstrators in the Engineering Department of Cambridge University, under Prof Ewing. We understand that Mr. Lamb, who was a distinguished student and collaborateur of Prof. Ayrton's at the Central Institution, has been appointed with a special view to the development of teaching in applied electricity. The engineering laboratory, which is now taking shape, will include electrical engineering as one of its features.

Atmospheric Electricity.—Meteorological observatories are generally ill adapted, by reason of dust and smoke, for observations on atmospheric electricity; and, with the view of inciting private individuals to such work, Herren Elster and Geitel, of Wolfenbüttel, have lately issued a *brochure*, in which they indicate the ends to be sought and the instrumental means. Three things demand attention: first, systematic observation and measurement of electricity in the open air at different times in the day, humidity and air-temperature being determined at the same time; second, measurement of the fall of potential with a clear sky; and third, measurement of the fall of potential and its change of sign during rain, &c. The instruments and methods recommended are such as present little difficulty for private persons.

Electric Traction at Bremen.—The Bremen Strassenbahn Gesellschaft has contracted with the Thomson-Houston International Electric Company for the electrical equipment of two-thirds of their Bremen system. The line that was in operation last summer at the Exhibition is to be retained, and a further line of four miles is to be equipped with six motor cars and as many tow-cars as may be required. The Bremen Company proposes to work their system by electricity as soon as the first portion is ready. The Bremen Strassenbahn Gesellschaft is the first tramway company in Europe to purchase outright an electric tramway. It will be remembered that an electric line was run very successfully by the Bremen Tramway in connection with the Thomson-Houston International Electric Company last summer. From June 22nd to October 15th, 1890, 586,518 passengers were carried.

Cable and Land Line Interruptions and Repairs.—

	Date of Interruption. 1891.		Date of Repair. 1891.
Mollendo-Arica-Iquique Cable	Mar. 5	.....	June 24
*Ceara-Pernambuco Cable	„ 14	.....	—
Saigon Bangkok Line	June 25	.....	June 26
„ „	„ 27	.....	„ 28
„ „	„ 30	.....	„ 30
„ „	July 2	.....	July 13
„ „	„ 16	.....	„ 20
„ „	„ 22	.....	—
*Siberian Lines	June 25	.....	June 25
„ „	July 11	.....	July 12
„ „	„ 17	.....	„ 18
*Cape St. Jacques-Thuan An-Haip-hong Cables	June 28	.....	—
Pernambuco-Bahia Cable	July 14	.....	July 22

* Not yet repaired.

Meteorological Telegrams.—The Pacific Postal Telegraph Company lately had a gathering of some 500 guests at the opening of a new telegraph office in San Francisco. After shortly describing the various instruments, the superintendent said he was often asked how long it took to telegraph to different places and get a reply. He would, therefore, now send telegrams to Portland, New York, Washington, Seattle, Tacoma, Canso (Nova Scotia), and London, inquiring about the weather. The first reply came from Portland in 3 minutes, "Weather fine"; the next from New York in 3 minutes 10 seconds, "Misty and warm"; Washington in 3 minutes 11 seconds, "Misty and warm"; Seattle in 3 minutes 21 seconds, "Misty and calm"; Tacoma in 3 minutes 28 seconds, "Misty, cool, and calm"; Canso (Nova Scotia) in 4 minutes 20 seconds, "Cold and misty"; while the answer "Misty and cold" came from London in 6 minutes 22 seconds.

A Combined Passenger and Freight Electric Tramway.—During the latter part of April a narrow-gauge electric railway, connecting the towns of Sissach and Gelterkinden, in Switzerland, was opened to traffic. The road is intended for both passenger and freight service, and accordingly differs in several respects from the various electric roads designed simply for passenger transportation. Its gauge is one metre, and its total length a little over two miles. For two-thirds of its length the road runs along the highway between the two towns; for the remainder of the distance a special roadbed had to be laid down. Power is supplied by a turbine plant located about half a mile from Sissach, and the dynamo, which is of the two-pole type, furnishes a current of 50 amperes at 500 volts. The current reaches the motor through an overhead line, the rails being used for the return circuit. The locomotive has two motors working independent axles through gearing, which reduces the revolutions of the axles to quarter of those of the motor shafts, which make 480 revolutions per minute. The speed ranges from 6¼ to 11¾ miles per hour.

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Insulating Compositions.—Patents for insulating compositions are being taken out very freely just at present. Thus, in patent 11,130 (1890), it is proposed to saturate fibrous substances with a drying oil (preferably linseed oil, previously partially oxidised by heating for some hours with litharge or other suitable oxidising agent), and then drying. This process being gone through again and again until the substance has increased at least 50 per cent. in weight. Amalgamating rolls running at a high speed are then brought into play, until a smooth and homogeneous mass is obtained. Some 25 per cent. of gutta-percha or india-rubber is then added, and the mass subjected to the action of amalgamating rolls until it is capable of being formed into a block or rolled out into thin sheets. The fibrous substance may be wood fibre, hemp, flax, jute, cotton, or silk. The following recipe is given in patent 12,013 (1890):—Sulphur, 7lb.; clean pipe-clay, 1½lb.; slate dust, 1½lb.; paraffin wax, 2oz. The pipe-clay and the slate dust are to be thoroughly mixed by grinding under heat, the paraffin wax being then admixed, and the combination worked up to a paste. It is then, after exposure to become dry and hard, ground into a powder, and the sulphur mixed therewith.

Personal.—We have received from Messrs. William Notman and Son, of Montreal, a remarkably fine specimen of the photographic art in Canada in the shape of an excellent likeness of Mr. Frederic Newton Gisborne, the energetic and well known General Superintendent of Government Telegraphs for the Dominion of Canada.—Mr. J. F. Albright, Managing Director of Crompton and Co. (Limited), has just returned after a very successful tour round the world. He started originally with the Iron and Steel Institute for the United States, and then went to Australia to look after the business of the Crompton Electric Supply Company of Australia. After spending some months in various parts of Australia, he went to Ceylon, and from thence to Calcutta. After this he proceeded to Colombo and Mauritius, *en route* for Durban. Making this his headquarters, he went up country to Pretoria, where his Company is about to carry out the lighting of the town.—Mr. C. J. Robertson, who in 1887 installed and has since then superintended the glow lamp factory of the firm of J. Bondewijnse, Middelburg, Holland, has severed his connection therewith, and is now partner in, and Managing Director of, the firm of Latzko and Scharf, glow lamp manufacturers, Vienna.

Gas Engines and Electric Light Installations.—"Having to inspect an arc and incandescent installation at Lille, supplied with current from a dynamo driven by a gas engine, I was able," says M. Witz, in a recent note in the *Comptes Rendus*, "to compare the quantity of gas consumed in this manner with that previously consumed by the lamps and regenerative burners employed in the illumination of the same locality. Some 16 arcs and 71 16 c.p. glow lamps replaced six powerful double regenerating See lamps, 91 ordinary, and 19 batswing burners. The electric lamps gave 15 per cent. more light than the gas lamps, a fact I was able to ascertain by comparative measurements of the illumination of the floor surface, and, in addition, they lit up a few places where there had not previously been any gas lamps. Now, things being so, the gas engine only consumed 21,500 litres (752 cubic feet) per hour, whilst the gas lamps consumed 26,500 litres (927 cubic feet). Thus, when we employ gas as the motive power for driving a dynamo supplying current to electric lamps we consume 17 per cent. less gas than we should if we burnt the gas at the burners, and we obtain much more light."

A Thousand Horse-Power Dynamo.—A somewhat peculiar dynamo for metallurgical work has recently been completed for the Willson Aluminium Company, of New-York. The machine is unusual, not only in size but in general construction, being a decided return to the early Gramme type. The frame of the machine consists of two massive castings, with salient pole pieces having wrought-iron cores both above and below the armature. The armature itself is 24in. in diameter, and 47in. long, and is formed upon a 5in. hammered steel shaft, resting in composition bearings 15in. long. The armature weighs 6,163 pounds, while the frame contains 11,000 pounds of castings and 7,000 of solid forgings. As the machine stands, with its present pulley, it weighs a little less than 30,000 pounds. The armature is a Gramme ring, with conductors formed of solid drawn copper, with a cross section of three square inches; the bars upon the periphery are rigidly bolted in place, and insulated from each other. The brushes are made to bear directly upon the armature. The designer estimates that the machine will have an output of 750,000 watts, if necessary. During tests recently made no heavy current was drawn from the machine, but when running on open circuit the heating of the armature was said to be so slight as to render it evident that Foucault currents and hysteresis were not formidable factors in its general efficiency, a rather surprising result with solid bar conductors.

The Capacity and Self-Induction of Overhead Telegraph Lines.—In a recent note in the *Comptes Rendus*, M. Massin calls attention to the lack of data with regard to the capacity and self-induction of overhead telegraph lines, caused by the difficulty of making the necessary measurements owing to the proximity of "live" wires. M. Massin, however, found means for obtaining these data for three circuits. A line, 18 kilometres long; iron wire, 3mm. in diameter; two wires about 40 centimetres apart, and 4·5 metres from the ground. B line, 50 kilometres. C line, 50 kilometres; copper wire 2·5mm. in diameter; two wires about 50 centimetres apart, and 5·5 metres from the ground. The following results were obtained:—

Line.	Kilometric capacity in microfarads with respect to earth.	Ditto of the looped wires.
A	·0097	·0070
B	·0099	·0069
C	·0092	·0065

The two wires have, therefore, when looped, seven-tenths the capacity of either separately. On underground lines the capacity is exactly halved. The coefficients of self-induction per kilometre of looped wire were found to be as follows:—Line A, ·0121 henrys; line B, ·0129 henrys; line C, ·0025 henrys.

The London County Council and Electric Lighting.—In the report of the London County Council for the year ending March 31, 1891, it is stated that a meter-testing station, with the necessary appliances, has been established by the Council at Nos. 42 and 43, Cranbourne-street, and an inspector has been appointed. A person has also been selected to act as caretaker of the station and to assist the inspector. The rent value of the premises, which are the property of the Council, is £240 a year; £717 has been expended in necessary alterations and repairs to fit them for the purposes of an electric meter-testing station; and the amount expended up to the present time for the apparatus required for testing is £1,012. It is expected that the station will shortly be in full working order. The Council has, since the date of the last annual report, received and dealt with 123 notices, many of which referred to works extending over large areas; and each of these has been separately considered, and, where necessary, special conditions have been attached to the Council's consent to such works. The Council has, during the year, sanctioned the laying of no less than 137½ miles of mains in streets and roads, in addition to innumerable service lines to particular consumers. Of these mains, 86½ miles were for currents of high tension and 51 miles were for currents of low tension. The Council has in all cases required that the mains should be laid under the footways wherever it was found practicable to do so, and that the covers of the street-boxes should consist of iron frames filled in with material to suit the paving. In consequence of an accident to two persons, in November last, through high-tension mains having, on account of defective insulation, come in contact with the cover of a street-box, the Council has, after communication with the Board of Trade, required in cases where high-tension mains are used, that each of the street-boxes shall be provided with an inner as well as an outer cover, the two to be insulated from each other as far as practicable, and that the outer cover shall be efficiently connected to earth, or that other adequate precautions shall be taken to prevent risk of accident through defective insulation. An official is employed to inspect the works of the companies in the public streets in order to see that the requirements of the Council are complied with.

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ELECTROMAGNETIC THEORY.—XIII.

BY OLIVER HEAVISIDE.

(*Continued from page 296*).

§ 73. We may now consider the practical meaning of the stress whose relation to the electric and magnetic forces has, under certain suppositions, been formularised. Go back to the foundation of electromagnetic theory, viz., the mechanical forces experienced by electrically charged bodies, by conductors supporting currents, and by magnets, intrinsic or induced. It is by observation of these forces in the first place, followed by the induction of the laws they obey, and then by deductive work, that the carving out of space into tubes of force follows; and now, further, we see that the localisation of the stored energies, according to the square of the electric and magnetic force respectively, combined with the two circuital laws, leads definitely to a stress existing in the electromagnetic field, which is the natural concomitant of the stored energy, and which is the immediate cause of the mechanical forces observed in certain cases. But the theory of the stress goes so far beyond experimental knowledge in some respects, although agreeing with it in others, that we could only expect it to be true if the theoretical foundations were also rigidly true in all respects. Such is not the case, however. To begin with, the way of expressing the action of ordinary matter merely by altering the values of the two ether constants, and by a fresh property, that of conductivity, is extremely bald. It is, indeed, surprising what a variety of phenomena is explained by so crude a method.

The objection is sometimes made against some modern theoretical developments that they are complicated. Considered as an argument, the objection is valueless, and only worthy of superficial minds. Whatever do they expect? Do they not know that experimental knowledge, even as at present existent, shows that the theory of electromagnetism, when matter is present, must, to be comprehensive, be something far more (instead of less) complicated than theory as now developed? The latter is, as it were, merely a rough sketch of a most elaborate subject, only small parts of which can be seen at one time.

In the next place, even if we take the stated influence of matter on the ether as sufficient for the purposes of a rough sketch, the theory of the stress should, except in certain relatively simple cases, be received with much caution. Why this should be so will be apparent on examining the manner in which the stress has been obtained from the circuital laws. If we investigate the subject statically, and, starting from certain mechanical forces regarded as known, endeavour to arrive at a stress which shall explain those forces, we shall find that the problem is essentially an indeterminate one. All sorts of stress functions may be made up which are precisely equivalent in their effects in the gross, that is, as regards translating or rotating solid bodies placed in an electric or magnetic field. To remove this indeterminateness a dynamical method must be adopted, wherein what goes on in the unit volume whilst its electric and magnetic states are changing, and the matter concerned is itself in motion, are considered. If our system of connections is dynamically complete and consistent, and is such that the flux of energy can be traced, then a determinate stress comes out, as we have found. The method is, at any rate, a correct one, however the results may require to be modified by alterations in the data. Besides that, the distribution of energy (electric and magnetic) in bodies is in some cases open to question; and a really speculative datum is that concerning the motion of the ether as controlled by the motion of matter. Now, this datum appears to be one which is essential to the dynamical method; the only alternative is the statical and quite indeterminate method. Our attitude towards the general application of the special form of the stress theory obtained should, therefore, be one of scientific scepticism. This should, however, be carefully distinguished from an obstinate prejudice founded upon ignorance, such as is displayed by some anti-Maxwellians, even towards parts of Maxwell's theory which have received experimental demonstration.

The stress theory can, nevertheless, sometimes be received with considerable confidence, if not absolute certainty. The simplest case is that of ordinary electrostatics.

§ 74. Let there be no magnetic force at all, and the electric force be quite steady, and the medium be at rest, and there be no impressed forces. These limitations bring the circuital laws down to

$$0 = k\mathbf{E}, \quad \ldots\ldots \quad (1)$$

$$-\operatorname{curl}\mathbf{E} = 0; \quad \ldots\ldots \quad (2)$$

that is, there must be no conduction current anywhere, and the voltage in any circuit must be zero. The first condition (1) implies that there is no electric force in conductors. We may, therefore, divide space into conducting and non-conducting regions, and our electric field is entirely confined to the latter. The second condition (2) implies tangential continuity of **E** at the boundary of the non-conductor, so that as there is no **E** in the other or conducting side, there must be no tangential **E** on the non-conducting side. The lines of force, therefore terminate perpendicularly on the conducting matter. Whether the conductors are also dielectrics or not is quite immaterial. The displacement also terminates normally on the conducting surface in the usual case of isotropy. Thus D, the tensor of **D**, measures the surface density of electrification, when the positive direction of **D** is from the conductor to the insulator. But in general it is the normal component of **D**, that is **DN**, where **N** is the unit normal vector, that measures the density of the electrification. Besides this, there may be interior electrification of the non-conductor, its volume density being measured by the divergence of the displacement. The arrangement of the electric force, so that the circuital voltage shall be zero throughout the non-conductor, and give the proper internal electrification, and the charges on the conductors, is uniquely determinate.

We have thus the ordinary case of a number of charged conductors in air, with the difference that the air, or parts thereof, may be replaced by matter of different permittivity. It is also to be noted that one non-conducting region which is entirely separated from another by conducting matter may be taken by itself, and all the rest ignored.

Now, first without replacing the air by matter of different permittivity, we see that there are two entirely different ways of considering the mutual actions of the conductors. The old way is analogous to Newton's way of expressing the fact of gravitation. We may say that any element of electrification ρ repels any other ρ' with a force

$$\rho\rho'/4\pi cr^2$$

if r be the distance between the two charges, and that the resultant of all such forces makes up the real forcive.

In the other way, appropriate to the philosophy of Faraday, as developed by Maxwell, these forces acting at a distance are mathematical abstractions only, and have no real existence. What is real is a stress in the electric field, of a peculiar nature, being a tension of amount U parallel to **E**, combined with an equal lateral pressure, and it is the action of this stress that causes the electrified conductors to move, or strains them, according to the way they are supported, when by constraints they cannot appreciably move.

Since the electric force is normal to the conducting surfaces, the stress vector is entirely a normal pull of amount U per unit area, and the motions or tendencies to move of the conductors are perfectly accounted for by this pull. They do not move because of electrical forces acting at a distance across the air, but because they are subjected to moving force on the spot by the stress terminating upon them.

Thus a charged soap-bubble is subjected to an external radial tension, and therefore expands; and so, no doubt, does a charged metal sphere to some small extent. The parallel plates of a condenser are pulled together. When they are very large compared with their distance apart, the force on either is

$$\tfrac{1}{2}\,\mathrm{E}\,\mathrm{D} \times \text{area},$$

$$= \tfrac{1}{2}\,\mathrm{E} \times \text{charge}.$$

Here E is the transverse voltage divided by the distance be-

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tween the plates, so that, if the plates be connected to a constant source of voltage, the attraction varies inversely as the square of the distance between them; whereas, if the plates be insulated and their charges constant, the attraction is the same at any distance sufficiently small compared with the size of the plates.

But by sufficiently separating the plates, or by using smaller plates, the displacement, which was formerly almost entirely between them will spread out, and will terminate in appreciable amount upon the sides remote from one another. By the pull on the remote sides thus produced the attraction will be lessened, and the further the plates are separated the more displacement goes to their backs, and the less is the attraction. When the distance is great enough it tends to be simply the attraction between two point charges. Thus the attraction between two distant oppositely charged conducting spheres, which varies closely as the inverse square of the distance, depends entirely upon the slight departure from uniformity of distribution of the electrification over their surfaces, whereby the normal pull on either is made a little greater on the side next the other than on the remote side. Also, the inverse square law itself, which is exactly true for point charges, is merely the ultimate limit of this operation.

Some attacks have been made on the law of inverse squares, especially in its magnetic aspect. But these attacks appear to have been founded upon misapprehension. The law is true, and always will be.

§ 75. In the above electrostatic application of the stress, it will be observed that the tension alone comes into play, at least explicitly, owing to the tubes of displacement terminating perpendicularly on the conductors. Thus each tube may be compared with a rope in a state of tension, pulling whatever its ends may be attached to. But the lateral pressure is needed to keep the medium itself in equilibrium, so that the only places where translational force arises from the stress is where there is electrification. The mechanical force is

$$\mathbf{F} = \mathbf{E}\,\mathrm{div}\,\mathbf{D} = \mathbf{E}\rho \quad . \quad . \quad . \quad . \quad . \quad (3)$$

per unit volume. This is the force on volume electrification, and is the result of the differential action of the stress round about the electrification, as in the case of the inverse square law between point charges, lately mentioned. The corresponding surface force is

$$\mathbf{F} = \tfrac{1}{2}\,\mathbf{E}.\mathbf{DN} = \mathbf{N}U \quad . \quad . \quad . \quad . \quad , \quad (4)$$

per unit area. Now, here **DN** is the surface equivalent of div **D**, so there is at first sight a discrepancy between the expressions for the force per unit volume (3), and per unit area (4), on bodily and surface electrification. How the coefficient $\frac{1}{2}$ comes in may be seen by taking the limiting form of the previous expression. Let there be a thin skin of electrification, of amount σ per unit area; **E** falling off from **E** outside to 0 inside the skin. Evidently the mean **E** is $\frac{1}{2}$**E**, so that the total force on unit area of the skin obtained by summation of the forces on the volume electrification in the skin, is not $\mathbf{E}\sigma$, but $\frac{1}{2}\mathbf{E}\sigma$. This is merely a mathematical harmonisation. From the point of view of the stress the difficulty does not present itself.

The harmonisation is simply evident when the layer is of uniform density, for the electric force will then fall off in intensity uniformly. It might, however, be suspected that, perhaps, the result would not come out quite the same if we assumed any other law of distribution, and kept to it in proceeding to the limit by making the skin infinitely thin. But a cursory examination will show that it is all right; for if **E** is the electric force within the layer, the electrification density will be $c\,(dE/dx)$ and the translational force will be $c\mathbf{E}\,(dE/dx)$ per unit volume, if x is measured perpendicularly to the skin's surfaces. Integrate through the skin, and the result is

$$F = \tfrac{1}{2}\,cE_1^2 - \tfrac{1}{2}\,cE_2^2 = U_1 - U_2,$$

where the suffixes refer to the value just outside the skin, on its two sides. In the present case the second term U_2 is zero (within the conductor), so that the result is the single normal pull of the tension on the non-conducting side.

§ 76. In this connection the old question of the depth of the layer of electrification on a conducting surface crops up. Has it any depth at all, and, if so, how much? The question is not so superficial as it looks, and the answer thereto lies in the application thereof. If a powerful mental microscope be applied to magnify the molecules and produce evident heterogeneity, the surface of a conductor would become indefinite; and unless the molecules were found to be very closely packed, it is evident that the displacement in the ether outside the conductor would not terminate entirely upon those molecules which happen to be most superficially situated, but that a portion of the displacement would go deeper and in sensible amount reach molecules beneath the first set, and an insensible amount might penetrate through many layers. Thus in a molecular theory the depth of the layer of electrification has meaning, and could be roughly estimated.

But the case is entirely different in a theory which deliberately ignores molecules, and assumes continuity of structure. A conductor is then a conductor all through, and not a heterogeneous mixture; and the surface of a conductor is an unbroken surface. The electrification on it is therefore surface electrification, and has no depth. For it to be otherwise is simply to make nonsense. It is desirable to be consistent in working out a theory, for the sake of distinctness of ideas; if, then, we wish to give depth to surface electrification, and still keep in harmony with Maxwell's theory, we must change our way of regarding a conductor, and bring in heterogeneity. Each view is true, in its own way; but as in the mathematical theory continuity of structure is tacitly assumed, we have a simultaneous evanescence of one dimension in the distribution of electrification.

The same question occurs in another form in the estimation of bodily electrification, when the meaning of volume density of electrification is considered. When air is electrified, it is probable that the electrification is carried upon the foreign particles suspended in the air, and it may be partly upon the air molecules themselves. In either case it is ultimately surface electrification, and quite discontinuous. But, merely for the sake of facility of working, it is desirable to ignore all the discontinuity, and assume a continuous and practically equivalent distribution of bodily electrification. Thus, as previously we saw surface density to be a kind of volume density, so now we see that volume density is a kind of surface density. When, therefore, we say that the translational force per unit volume is $\mathbf{E}\rho$, where **E** is the electric force and ρ the volume density of electrification, we really mean that $\mathbf{E}\rho$ is the average, obtained by summation, of the translational forces on the multitudinous electrified particles, every one of these forces being itself a differential effect, as before seen, viz., the resultant of the unequal pulls on different parts of a particle exerted by the electric stress.

As ether has some of the properties of matter, and as electrification is found in association with matter, it is possible, however improbable, that ether itself may become electrified. But of this nothing is known. Nor, more importantly, is it understood why the electric stress appears to act differently on positive and on negatively electrified matter. But, if we begin to talk about what is not understood, we enter illimitable regions. Men who are engaged in expounding practical problems sometimes make the boast that they take and discuss things as they are, not as they might be. There is a sound of specious plausibility here, which is grateful and comforting; but, as a matter of plain fact, questions of physics never are theorised upon as they are, but always as they might be. It is a necessity to limit the field of inquiry, for to take things as they are, or as they seem to be, would lead at once to a complete tangle. For the problem, as it presents itself in reality, there is always substituted a far simpler one, containing certain features of the real one emphasised, as it were, and others altogether omitted. The juveniles, who take things as they are, do not do it; they only think so. They may strain out a few gnats successfully, but swallow, quite unawares, all the camels in Arabia. But the principle and practice of limitation and substitution is the same all over; in politics, for instance, where a fictitious British Constitution does brave duty, as a scarecrow, and in other useful ways.

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PRACTICAL ELECTRO-MAGNETIC UNITS.

BY PROF. JOHN PERRY, F.R.S.

SIR: This note was written some years ago, and has been brought forward at various meetings of the British Association Committee on Electrical Standards. The author, to quote his own words, sees so many disadvantages as well as advantages in the system proposed that he begs that the note may be published and discussed by practical men before any steps are taken by the Committee. I should be glad if, in accordance with his wishes, you could insert it in *The Electrician*.—Yours faithfully,

R. T. GLAZEBROOK,
Secretary Electrical Standards Committee of the British Association.

Men who use the ohm, ampere, and volt in their electric calculations object to the conversion of these to C.-G.-S. units when making calculations on the magnetic circuit of the dynamo-machine or of transformers and other electro-magnetic contrivances. It results that new and ill-defined systems of units are getting into use. There are "Kapp" lines of magnetic force to the square inch, for example; many scientific men, acquainted with workshop methods, are already using C.-G.-S. lines per square inch.

It is with great diffidence that I make the following suggestions. When my students make calculations on the mechanical design of electric machines they use the inch as the unit of length, and the weight of one pound in London, as the unit of force. When they make calculations on the electric and magnetic circuits of the same machines they use 1cm. as the unit of length, and the watt as the unit of power. I have found that they do not object to these systems, and, with all due deference to members of the Committee who would insist on the general use of C.-G.-S. units even in mechanical engineering, I beg to say that the inch and pound must continue to be used by my students in their machine design,* and if I make any alteration it will rather be to use 1in. as my unit of measurement in making electro-magnetic calculations, than to use C.-G.-S. units in my practical mechanical engineering work. In what follows I will assume that practical men do not object to the use of the centimetre as a unit of length in making electro-magnetic calculations.

At present:—

I. A wire 1cm. long, moving with a velocity of 1cm. per second across unit (C.-G.-S.) field, generates the unit E.M.F. or 10^{-8} volt.

II. If a wire moving across unit field at 1cm. per second is conveying unit current (10 amperes), the power used (or developed) per 1cm. of its length is one erg per second (or 10^{-7} watts).

The integral of the magneto-motive force all round any elementary solenoid in a magnetic circuit is obtained by dividing the current turns (the unit current turn is 10 ampere turns) by 4π. We see, then, that in dealing with the magnetic circuit of a dynamo machine, and in dealing with transformers, in dealing with the induction produced by currents or with electromotive forces produced by induction, whether by movements of coils in magnetic fields or by variable magnetic fields, or by both together, we find at present, that if the ohm, ampere, volt, and watt are our electric units, then $4\pi/10$ or 10^8, or $4\pi \times 10^{-9}$, enters into most of the mathematical expressions, either as a multiplier or divisor. Just at present, the calculations involve other complications, because the true ohm, ampere, and volt are not in practical use.

I would suggest that the practical unit of magnetic flux (or induction or force), be 10^8 C.-G.-S. units, and that it receive a name. That the magnetic permeability of air shall no longer be assumed to be unity, but, in the practical system of measurement, be tabulated like the permeability of any other substance; —the permeability of air will be $4\pi \times 10^{-9}$, and that in future no substance shall have unit permeability. That the unit of total magnetomotive force in a magnetic circuit be 1 ampere turn. The unit of magnetomotive force gradient would be 1 ampere turn per centimetre. It will follow that:—

I. A wire one centimetre long, moving at 1cm. per second across unit field, generates an E.M.F. of 1 volt.

II. If a wire 1cm. long conveys 1 ampere, the power used (or developed) in moving it across the unit field at 1cm. per second is 1 watt.

III. A magnetomotive gradient of one ampere turn per centimetre produces unit induction (magnetic flux or force) per square centimetre if the permeability is 1.

IV. Change of induction (magnetic flux or force) at the rate of one unit per second produces 1 volt per turn of wire.

If it were allowable to use 1in. as the unit of length, and this would delight every electrical engineer in English-speaking countries, we can, by altering the above units, have all our rules quite simple, such as:—

I. A wire 1in. long, moving with a velocity of 1in. per second across unit-field (per square inch) generates the E.M.F. of 1 volt.

II. If a wire moving across unit-field at 1in. per second is conveying 1 ampere, the power used or developed per inch of its length is 1 watt.

III. The integral of the magnetomotive force all round any elementary solenoid in a magnetic circuit is exactly the number of ampere turns.

IV. Change of induction (magnetic flux) at the rate of one unit per second produces 1 volt per turn of wire.

* No man can think and design in two distinct sets of units. The mechanical engineer must either use the units so universally employed in workshops and engineering societies, or else the C.-G.-S. units. He cannot habitually use both. When a student enters workshops he is already frightfully handicapped by the mere fact that he has been to college, for there is still a great prejudice among practical engineers against education and "book knowledge." The professors who talk so glibly about the absurdity of teaching students in the ordinary units, and who insist on C.-G.-S. units, have no conception of the martyrdom to which they would devote a poor apprentice, who will in any case find himself in a sufficiently difficult position when he enters the shops. I do not deny that French is a more beautiful language than Chinese, but if I were sending a man to China to spend his life among Chinamen, I would not insist on his having a knowledge of French, and I would especially object to his being taught to ridicule and altogether neglect the Chinese language.

NOTES ON PERMANENT MAGNETS.—III.*

BY PROF. SILVANUS P. THOMPSON, F.R.S.

Methods of Magnetising.—The ancient methods of magnetising, including "single-touch," "double-touch," "divided-touch," "circular touch," in all their varieties may be dismissed as obsolete. The only methods needing attention are those based upon the use of electric currents. Arago discovered this way in 1820, and magnetised steel needles by inserting them within a spiral coil connected to a voltaic battery. Elias, of Haarlem, in 1844, proposed a useful variation of this process. Instead of winding the wire in a long tubular spiral, he coiled it in a compact ring of many layers, which could be slipped loosely over the piece of steel which was to be magnetised, and then moved along it from end to end, so as to bring every part successively into an intense magnetic field. In 1846, Böttger suggested a modification for special application to horse-shoe magnets, consisting of two coils oppositely wound, to be slipped over the two polar ends simultaneously. Sinsteden used, for magnetising horse-shoe forms, a powerful two-pole electro-magnet, against the polar ends of which the steel horse-shoe was placed, and while thus *in situ*, stroked the horse-shoe in the direction from bend to poles with an armature of iron resting across the two limbs. Van der Willigen, in his remarkable treatise† on the Haarlem magnets forged by Van Wetteren, describes the method used for these famous magnets. The steel horse-shoe is placed with its poles against the pole-pieces of a Ruhmkorff's electro-magnet, and the current from ten or twenty Bunsen cells is then turned on and off three or four times. The current being cut off, the horse-shoe is then raised into a vertical position, and the keeper is slid across its poles

* Parts I. and II., *The Electrician*, July 3 and 10.

† Van der Willigen. *Sur le Magnétisme des Aimants artificiels.* (Archives du Musée Teyler, Haarlem, Vol. IV., 1878.)

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before these are removed from contact with the electro-magnet. The magnet is then in a super-saturated state, holding on to its keeper with a pull about 30 per cent. greater than the permanent pull which it will exhibit. For larger magnets, Van der Willigen made a simultaneous use of the Ruhmkorff electro-magnet as described, and of an Elias's ring, which he slid to and fro from one end to the other of the horse-shoe, from 20 to 100 times, whilst the electro-magnet was also in action.

For small bar magnets and compass-needles it suffices to draw them over the poles of a large electro-magnet, each extremity of the piece of steel being finally touched against the pole of opposite kind, and pulled off normally. For straight bars of considerable size, Van der Willigen used the same electro-magnet, adjusting the distances between the polar faces to correspond to the bar to be magnetised, and then applied the same process as for horse-shoes, but, of course, without applying a keeper.

One process, known as Hoffer's method, consists in stroking the steel horse-shoe from the poles to the bend with an iron rod laid across the limbs, whilst it is in contact with the poles of another previously-magnetised horse-shoe. Van der Willigen, who examined this method, found it faulty and even harmful. It set up inequalities in the distribution of the magnetism, and diminished the effective power of magnets previously magnetised as described above.

Another process, which has been suggested at various times as an improvement on the ordinary processes, is to subject the magnet to powerful magnetising forces during the act of hardening. Robinson placed the steel bars red hot against the poles of a strong magnet, and in this position applied cold water to the bar. Holtz says that thick steel bars so magnetised during sudden cooling are twice as powerful as those magnetised in the cold; and that thin bars are three times as powerful. Aimé and Hamann have also advocated this method; which, however, does not seem to have any real advantages.

Moser, in 1838, made a comparative trial of various methods, as applied to a parallelopipedal steel rod weighing 12 ounces. He measured the degree of magnetisation by the method of oscillations, observing the time required for one complete swing. From the duration of the oscillation the relative strengths are calculated. The results of eight methods, each better than the preceding, are given as follows :—

—	Time of one swing. (sec.)	Relative strength.
1. Knight's method of "divided-stroke," using two permanent magnets; 20 strokes on one side of rod only	22·13	1
2. Same, repeated on all four sides	14·87	2·21
3. Same, repeated with masses of iron laid under each end of the bar	14·63	2·29
4. Same, repeated while bar placed on top of a reversed steel magnet	12·13	3·33
5. Mitchell's method of "double-stroke," using two separate steel bar magnets	11·13	3·95
6. Same, using a steel horse-shoe	10·19	4·71
7. Aepinus' method of "circular-stroke," using same horse-shoe magnet	8·75	6·39
8. With an electro-magnet: rod laid on two iron pole pieces on the poles of the electro-magnet, and while here stroked with steel horse-shoe; the current of the electro-magnet then turned off, and rod then lifted off	8·0	7·62

These experiments leave no doubt as to the superiority of the modern method over the ancient ones.

Constancy of Magnets.—It by no means follows that the magnet which shows the greatest amount of permanent magnetism will be the most constant in its retention of the same. Magnets lose their magnetism from many causes, such as accidental shocks, contacts with other magnets or pieces of iron, changes of temperature, slow annealing of the steel, and the like. The relation of these influences to the quality and temper of the steel, and to the dimensions of the magnet, are not very well known, but some information exists.

Gray,* using glass-hard magnets, found the percentage of loss of magnetism due to a small demagnetising force (that of unit field) to vary widely for magnets of different lengths. A bar (10 diameters long lost 0·8 per cent.; one 20 diameters long lost 0·6 per cent.; 40 diameters long, 0·5 per cent.; whilst one 100 diameters long lost about 0·44 per cent.

Bosanquet† using a considerable number of magnets made (on February 8th, 1885) from the best cast steel, as hard as they could be made, found the following fall in magnetic moments :—

February 18.....12,539	March 15 11,767
March 3.....11,822	April 6 11,620
September 18.....11 119	

Lamont‡ made an investigation, lasting eleven years, as to the constancy of the magnets used in the Observatory at Munich for the daily magnetic measurements. These magnets had already been repeatedly alternately immersed in warm and cold water, but had not attained by this process a state of constancy, as the following figures show. The losses are given in decimal parts of the whole magnetic moment :—

——	1848.	1849.	——	1848.	1849.
January	0·0000	0·0000	July	0·0028	0·0016
February.....	0·0003	0·0001	August	0·0032	0·0022
March	0·0003	0·0002	September ...	0·0028	0·0022
April	0·0008	0·0005	October	0·0017	0·0013
May	0·0014	0·0007	November ...	0·0009	0·0007
June	0·0022	0·0011	December ...	0·0005	0·0001

The total decrease in various years, also in terms of the whole magnetic moment as unity, was as follows :

1847	0·0174	1853	0·0099
1848	0·0169	1854	0·0103
1849	0·0103	1855	0·0081
1850	0·0091	1856	0·0099
1851	0·0113	1857	0·0071
1852	0·0079	1858	0·0063

According to Barus,§ mean atmospheric temperature, acting on freshly quenched steel for a period of *years*, produces a diminution of hardness (with consequent loss of permanent magnetism) about equal to that which would be caused by the action of a temperature of 100°C. acting for a similar period of *hours*.

Some persons have sought to explain the slow decay of magnetism by reference to chemical changes of the surface due to oxidation, moisture, &c., and have proposed to prevent such decay by gilding, silvering, or lacquering the surface of the magnet. Such remedies are entirely ineffectual, and the supposition on which they are based is erroneous.

Cheesman observed the percentage loss of magnetism caused by percussion, the magnets being allowed to fall from a height, with the following results :—

Brand and temper.	Height of fall in metres.	Percentage loss of magnetism.
Steel wire, soft	1·5	30
,, ,, mechanically hardened	2·0	44
,, ,, ,, ,,	3·0	57
Steel rod, mechanically hardened	2·0	52
,, ,, ,, ,,	7 times, do.	81
Iron wire, mechanically hardened	2·0	84
,, ,, ,, ,,	3 times, do.	95
,, ,, soft	2·0	83
,, ,, ,,	3·0	99
Iron rod, soft	2·0	97
Steel wire, glass hard	3·0	6
,, ,, ,,	3·0	4

* *Phil. Mag.*, Vol. XX., p. 484, 1885.
† *ib.*, Vol. XIX., p. 57, 1885.
‡ Lamont's "Handbuch des Magnetismus" (1867), p. 410.
§ *Phil. Mag.*, Nov. 1888, p. 403.,

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W. Brown,* using magnets made from silver steel, all 10 centimetres long, endeavoured to find a relation between the temper of the magnets and the percentage loss of magnetism due to percussion after the magnets had been laid aside for various periods of times. His results are embodied in the following table, from which it will be seen that the glass-hard temper appears to be the most constant in this respect. It is less certainly shown that long magnets are more constant than short ones.

Temper.	Diameter ratio $\frac{\ell}{\delta}$.	Specific magnetisation σ.	Loss per cent. due to percussion after lying aside for				
			1 hr.	20 hrs.	44 hrs.	1 mth.	3 mths.
Glass-hard...	33	41	1·98	2·0	1·95	1·04	0·8
„ „	50	45	2·96	3·2	1·48	1·00	0·0
Yellow	33	44	6·03	6·1	4·8	5·4	6·2
„	50	46	4·0	3·5	3·76	2·6	4·0
Blue	33	54	11·8	10 8	9·71	11·8	7·5
„	50	71	8·2	8·2	8·18	7·5	8·7

Strouhal and Barus, who have made so many researches upon the physical properties of steel, have examined the question of magnetic constancy in relation to form, temper, and exposure to fluctuations of temperature. They found that a glass-hard magnet, 119 diameters long, lost 30 per cent. of its magnetism when heated for six hours in steam at 100°C, but the same magnet, when re-magnetised, and again heated in steam, now only lost 5·3 per cent. The loss of magnetism on the first heating was found to vary in magnets of different lengths.

A magnet of 119 diameters' length lost 30 per cent.
„ 108 „ „ „ 28 „
„ 35 „ „ „ 49 „
„ 14 „ „ „ 67 „

In every case after protracted heating in steam, a condition was attained in which neither the specific magnetisation nor the specific resistance (*i.e.*, the hardness as measured electrically) showed any appreciable further change. These investigators came to the conclusion that magnets so treated possess a special fixidity; and resist not only changes of temperature but mechanical shock, better than magnets prepared in any other way. As an example, they took a short magnet 2·5 centims. long, 0 4 centims. wide, and 0·3 centims. thick. This was boiled in water for four hours: then magnetised and kept two hours longer in steam. Its magnetic moment was then observed, after which it was laid on a wooden log, and violently beaten 50 times, both lengthways and sideways, with another mass of wood. It then showed a diminution of only $\frac{1}{500}$; and after a repetition of the beating only showed a loss of about $\frac{1}{400}$. In another experiment a tubular steel magnet was made glass-hard, magnetised, then heated for 30 hours in steam, re-magnetised and heated for 10 hours more in steam. This magnet when allowed to fall 10 times, on its ends, from a height of 1·5 meters, showed a permanent diminution of only $\frac{1}{4756}$ of its magnetism. It is accordingly recommended that all magnets for use in magnetic observations should be prepared as follows:—*Make the magnets glass-hard: then place in steam at 100° for 20 or 30 hours, or longer for very massive magnets. Then magnetise as fully as possible and then heat again for five (or more) hours in steam.* Such magnets will then be as constant as they can be made.

In quite another way Mr. G. Hookham† has sought to obtain magnets of constant power, for use in his electrical meters. A number of bar-magnets of tungsten steel are fitted into cast iron pole-pieces which nearly meet, so constituting a nearly-closed circuit. After these are fitted on, a magnetising current is sent round the bar-magnets to saturate them as fully as can be done. They are then mechanically hammered, and a weak de-magnetising current is sent through the coils, reducing the magnetism by about 10 per cent. Then for many months the magnet will show no tendency whatever to lose; indeed, it may slightly gain.

* *Phil. Mag.*, Vol. XXIII., p. 293, 1887.
† *Journal* Institution Electrical Engineers, Vol. XVIII., p. 688, 1889.

THE FRENCH MEDITERRANEAN CABLES.

The following is a translation from *Le Petit Marseillais* of July 13th. Cable-laying is, in these days, such a matter of routine that the difficulties it presented less than half a century ago may be worth recalling:—

The Chamber is about to vote a grant for the two new telegraph cables between Marseilles and the African coast—one from Marseilles to Oran and the other from Marseilles to Tunis. These new lines will increase to seven the number of the submarine wires which connect the metropolis with our great trans-Mediterranean colony, all of which land at Marseilles.

The first attempt took place in 1854. We had not the boldness then to undertake long distance lines, and it was therefore resolved to carry the line *via* Corsica and Sardinia, so as to have to submerge but relatively short lengths of cable—that is to say, Spezia-Corsica, Corsica-Sardinia, and Sardinia-Bona. The two first sections of the cable were laid without difficulty. The protective sheathing consisted of six iron wires ·008m. = in diameter. The weight of the cable was 5 kilogrammes per metre, an enormous weight necessitated by the heavy iron sheathing. It was next attempted to submerge the third portion between Cagliari and Bona, a distance of 200 kilometres; so that the weight of the cable was nearly 12,000 tons. The depth of the sea at one part of the track is from 2,800 to 3,200 metres. On arriving at the middle of the course where the greatest depths exist, the cable, dragged by its own weight, ran out with extreme rapidity, the breaks being powerless to hold it, and broke.

The second attempt was not more successful; the cable being paid out more rapidly than had been expected it was found too short, and it became necessary to stop laying when over a depth of 400 fathoms, and the ship did not possess buoys to enable the cable to be recovered and relaid. This was so much cable thrown into the sea as a pure loss. The two first sections of the cable worked on and off until 1863.

In 1857 the work of laying the third section was undertaken for the third time. On this occasion the dimensions were reduced, and consequently the weight of the cable, which had four conductors, was less. Each of these conductors consisted of four fine copper wires, and formed a spiral, covered with two layers of gutta-percha. These cores were placed together, and surrounded with a covering of hemp forming a bed for the 18 iron wires ·003m. = in diameter. For the shore ends the 18 iron wires were replaced by 12 galvanised wires ·005m. = in diameter. The cable was submerged between Cape du Garde, near Bona, and Cape Teulada, Sardinia. The work, commenced on September 7, 1857, at 8 p.m., owing to the calm weather, was finished next day at 10 p.m. When the ship was still 20 kilometres from the coast of Sardinia, the failure which characterised the second expedition was almost reproduced; the cable was too short, and it was necessary to join on a length of lighter cable, which was replaced a month afterwards by one of the same type as that of the rest of the line. During the laying it was necessary to stop two or three times to repair broken external wires. The cable running out with a speed much greater than that of the ship, the length submerged exceeded by about 40 per cent. the distance run by the vessel. This determined the engineers to change the route, and the cable was landed at Cape Teulada, in place of Cape Spartiventa as had been decided. The cable worked for about two years. The second cable was laid in 1861. It was composed of two sections, one from Port Vendres to Mahon, 418 kilometres, and the other from Mahon to Algiers, 426 kilometres. It only lasted one year.

The third cable was laid in 1864. On this occasion it was believed that every precaution had been taken, and none doubted a successful result. A foreign manufacturer had been chosen, and the cable had been constructed on a new model, which would not, it was said, give rise to any mishap. The cable was to be laid between Carthagena and Oran, and had been ordered from Messrs. Siemens, the manufacture being specially inspected by an engineer of the French Administration. A ship, the "Tenth December," had been bought expressly for the purpose of laying, and the then Director-General of French Telegraphs wished to preside himself at the installation of the new submarine line. The cable was composed of a copper conductor, surrounded by three layers of gutta-percha. Upon the gutta-percha were laid in opposite directions two layers of hemp, covered with a copper band, so laid on that one turn covered half of the previous turn. The total length was 300 kilometres, and the weight 200 kilogrammes per kilometre. The laying took place without serious accident, but the line only worked for a few hours, the cable breaking a few kilometres from the Spanish coast. Not discouraged, in 1865 the fourth cable was laid between Marsala, Italy, Biserta, and Tunis. It worked just two years. The fifth was laid between Bona and Marseilles by an English company in August, 1870; it is still working, as are also the four others which were subsequently laid in 1871, 1879, and 1880.

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The demand for technical education is being actively met in London by the establishment of carefully devised polytechnics and technical institutes. We use the term "demand" in its economic, rather than its literal sense, for one of the chief difficulties in dealing with this important matter is that the persons for whom these institutions are founded are unable, if only on account of their youth, to define or even to express their needs. A praiseworthy attempt was made by the establishment of the Science and Art Department to supply something of the kind, but, instead of making an endeavour to find out what was wanted, the promoters assumed that nothing could be better than the best, and so overshot the mark, and have failed to reach those classes whose requirements are now being studied and provided for. The Science and Art Department, in spite of its mischievous system of payment by results, has done very good work, as is shown by the report which was presented to Parliament a few days ago, and for the sake of this work, and of its value to the country, we are reluctant to criticise it; but, knowing how much an eager learner will make of the smallest facilities for scientific study, we are inclined to attribute a large share of the success to the students themselves, who have risen above the cramming and the examination papers, and have acquired a large amount of useful and thorough science.

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The City and Guilds of London Institute are doing work of immense value, and they not only reach the artisan classes and the apprentices, but carefully lay out a programme having some regard for their actual requirements. But they cannot help doing higher work at the same time, and there is a strong temptation to develop this at the expense of the strictly technical teaching. A difficulty of a similar character has been met with in the building of industrial dwellings. Philanthropists, shocked at the dirt, squalor, and overcrowding in the slums, raised large blocks which they imagined to be excellently suited for the poorest classes, who, it was thought, would speedily flock to them. But the so called sub-professional class were more ready to occupy them, and the dwellers in the slums were found not only to be unwilling to change their mode of life, but to be unconscious of some of its worst evils. No one grudged the use of this accommodation by clerks and governesses, but until closer attention and further experience showed how these buildings should be constructed, the misery which originally excited the philanthropy was not touched.

A priori reasoning is as likely to miss the mark in the matter of technical education, as it is in physical science. If the premises be true, and the reasoning be accurate, some real result will be reached; but it may not be the one desired. The method of experiment, nearly always the more costly, is undoubtedly more sure. Such experiments have been made, and a study of their results is very interesting. A most important example is to be found at the Polytechnic in Regent-street, which, begun in 1873, was transferred to its present quarters in 1882. In that year Mr. BESANT'S "All Sorts and Conditions of Men" was published, and everyone knows how the ideal People's Palace was soon realised with most of its pleasant details in the Mile End-road. For various reasons, it was soon found that the leading principle of recreation was apparently impracticable, and was probably before its time. A large investment was made in bricks and mortar, and such an investment, instead of yielding interest, entails a considerable cost for up-keep. Endowment was either forgotten or it was imagined that the scheme would pay its own way. When serious difficulties arose, the Drapers' Company and the Charity Commissioners came to the rescue, and it was recognised that, while the East Londoner's "capacity for innocent enjoyment" had not been clearly estimated, there was no doubt that the work-a-day departments in which book-keeping and shorthand were taught, were not only thoroughly appreciated, but were nearly, if not altogether, self-supporting. This result is instructive, and the details of the experience which such important experiments provide have not been lost sight of in the movement for establishing polytechnics and technical institutes in the more crowded parts of London. It is clearly recognised, in the first place, that, as with the highest branches of learning, education cannot be self-supporting, but must receive external assistance. The scope of the work has in several cases, and we hope will in others, be strictly limited to the classes for whom it is intended. Thus, we understand that at the People's Palace a condition for receiving a lad for training as a mechanic is that his parents do not earn more than £200 a year. Many persons will object to such a limitation, but the case is very similar to that of a hospital, which is not intended for, and is justified in rejecting, those who are able to command the services o a doctor. But such limitations are, to a certain extent, artificial, and the true way to reach and to retain the young artisan is to discover, by most careful observation, his exact requirements and those of the class to which he belongs. A scholarship by which, as by a stepping-stone, some exceptionally brilliant student may be passed on to a higher institution, will not necessarily tempt either the teacher or his class to aim too high, and need not in any way introduce the very inexpedient system of payment by results.

Having set on foot a course, or a number of courses, of technical study and training, whether for boys and girls between their schooling and their trade, or for apprentices after their work, recreation naturally follows, and a systematic and well-organised department is to be found in connection with all the polytechnics, though assuming different orders of importance in various localities.

If the complicated difficulties of piece-work could be overcome, and each artisan, after a good training at a technical institution, could, as *The Times* of Monday says, come to love excellence for its own sake, and be proud of his power of producing it, there would be but little difficulty about long hours, and there would, if he desired it, be plenty of time for recreation. By the better training which is now being provided, the quality of the work done should constantly improve, and the revival of the element of personal pride of the worker in his own handiwork may reasonably be looked for; a pride which is stamped on the best workmanship of to-day, but which was far more prevalent and characteristic before the days of trades unions. A more noble ideal than is taught in Hyde Park would be a trades union in which every member must have passed through a technical institute, and must after he has served his time, show, and afterwards maintain, a certain proficiency in his craft.

THE HISTORICAL DEVELOPMENT OF THE INDUCTION COIL AND TRANSFORMER.

BY DR. J. A. FLEMING, M.A.

(Continued from page 302.)

§ 15. **Foucault's Experiments with Two Coils.**—In the *Comtes Rendus* for 1856 (Vol. XLII., p. 215), Foucault describes an interesting experiment which he made with two Ruhmkorff induction coils. He desired to obtain long sparks by adding together the potential of two induction coils. With this object he joined the primary circuits of two similar coils in parallel, and operated them by the current from one and the same battery. Under these circumstances the contact breakers did not vibrate in step, and the secondary spark length, resulting from joining the two secondary circuits in series in the proper way, was not the sum of the lengths of the separate secondary sparks. He discovered an ingenious way of making the contact breakers keep in step. This was effected by joining a piece of wire across from the end of one primary coil to the similar end of the other, this junction being effected between the contact breaker and the beginning of the primary coil. When this was done each hammer kept the other in step with itself, and, on joining up the secondary circuits in series in the proper manner, he obtained a secondary spark double in length (viz., 18 or 20 mm.) of that of each coil separately.

§ 16. **Stöhrer's Induction Coil.**—In 1854 Emil Stöhrer directed his attention to the improvement of the induction coil,* and produced a form of coil which is represented in Fig. 23. The instrument consisted of a primary wire and core of divided soft iron arranged in a vertical position, the iron wires being of 1mm. diameter, and standing loosely in a cylinder of wood so that they could be removed one by one if desired. The iron wires were varnished with shellac. The primary coil consisted of six layers of double covered wire 1mm. in diameter, the height of the whole spiral being 20 centimetres, and its diameter over all 50mm. The secondary coil consisted of three independent coils wound

* See *Poggendorff's Annalen*, May, 1856; also *Phil. Mag.*, 1857, Vol. XIII., 4th series, p. 55.

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on separate bobbins made of varnished paper with cheeks of pear-tree wood. The wire was insulated with silk and well varnished, and insulated with a mixture of wax and resin. Stöhrer employed an independent electro-magnetic contact breaker, and a condenser of which the dielectric consisted of waxed cloth. He obtained good secondary sparks 12 or 14 "lines" in length. He tried producing, as Sinsteden had suggested, an arc light between coke points by means of the secondary discharges, but he was not aware of the previous results of Callan or of Page in this respect, and his coil evidently furnished too small a "quantity" of current to enable him to obtain an arc.

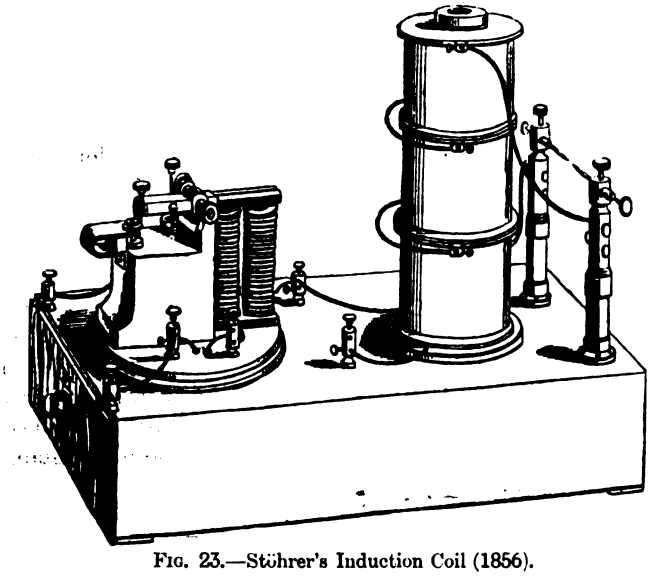

FIG. 23.—Stöhrer's Induction Coil (1856).

§ 17. **J. N. Hearder's Induction Coils.**—Mr. J. N. Hearder, of Plymouth, began, in December, 1855, the construction of induction coils, and his Papers describing his work are to be found in the *Philosophical Magazine* for November and December, 1856 (4th series, Vol. XII., p. 377).* Hearder had his attention drawn to the subject by the Paper of Grove in 1855, to which reference has been made already, on the employment of a Leyden jar in connection with the secondary circuit, and this Paper stimulated him to examine the construction of Ruhmkorff's induction coil. After many experiments he was successful in producing a coil for which he obtained a silver medal from the Royal Cornwall Polytechnic. It appears that up to the time of Hearder's experiments he (Hearder) had not, apparently, seen any one of Ruhmkorff's induction coils capable of giving a greater length of secondary spark than three-quarters of an inch. Hearder adopted sheet gutta-percha as his insulating material for the secondary coil, and he describes the chief differences between his own and Ruhmkorff's coil as follows:—He says (*Phil. Mag.*, Vol. XIV., 4th series, 1857) that Ruhmkorff's secondary wire was insulated with cotton, whilst he used silk-covered wire. Ruhmkorff employed shellaced paper between the layers of the secondary coil, whilst he used sheet gutta-percha or thin vulcanised sheet india-rubber. He also claims that he improved the iron core by using smaller iron wires than Ruhmkorff, and that, in place of oiled silk for the condenser dielectric, he substituted vulcanised india-rubber, gutta-percha, or varnished cartridge paper. He also states that he improved the contact breaker by using a stiffer spring, the rate of vibration of which he could alter, within certain limits, at pleasure, by means of a screw.

Hearder noted particularly the limitation imposed by the tendency to discharge from layer to layer of the secondary coil over the ends of the layers of insulator, and he prevented this by extending the sheet gutta-percha placed between the several layers of wire a good way beyond the wire windings, so that the discharge would have to take a longer path through air to get round. A considerable controversy sprang up between Mr. J. N. Hearder and another improver of the induction coil, Mr. C. A. Bentley, as to who was the first to suggest these modifications, and was continued with some bitterness between them (see *Phil. Mag.*, Vol. XIII., 1856, p. 325). Bentley's description of his coil is to be found in the *Philosophical Magazine* for 1856 (Vol. XII., 4th series, p. 319). He constructed a coil capable of giving secondary sparks two inches long in air when the primary current was produced by four or five Grove's cells. Bentley also adopted sheet gutta-percha for the insulation of the various layers of the secondary coil, but whether before or after Hearder it is difficult to say. He employed an electro-magnetic break having a very stiff spring to the hammer, the time of vibration of which he could vary at pleasure. He used also a condenser made of tinfoil and varnished paper.

Hearder constructed about this time a coil some 12 inches in length, in which the secondary circuit had a length of three miles, and from which he obtained secondary sparks about three inches in length. He noted that if the discharge was taken between fine platinum terminals not more than 0·5 inch apart, the negative terminal became white hot very soon, and began to melt. He made many experiments on discharges in air and in vacuo between terminals of different forms.*

Hearder published a Paper in the *Philosophical Magazine* for 1857 (Vol. XIII., p. 325), in which he makes many observations on the heating power of the secondary discharge, both when the terminals were connected to a Leyden jar in the manner described by Grove, and when they were not. He found that whereas the simple secondary current could not, under certain circumstances, heat a few inches of platinum wire red hot, the mere interposition of a Leyden jar across the secondary terminals caused the platinum wire to be heated to redness, or to be fused, thus showing an increase in the quantity of each discharge.

Bentley asserted that he had independently adopted these same improvements as Hearder, and that, by following this mode of construction, Mr. Ladd had obtained sparks 4½ inches long. The points at issue between these inventors are not very important except as showing that several minds had addressed themselves to improving Ruhmkorff's coil, and that the causes limiting the sparking distance were gradually being generally understood.

§ 18. **Ritchie's Induction Coils.**—Mr. E. S. Ritchie, of Boston, U.S.A., began apparently to study the construction of the induction coil in or about 1857, and, probably, not knowing what had been done by Poggendorff, he again brought forward the suggestion of insulating the secondary coil vertically instead of horizontally. A Paper by Ritchie is to be found in *Silliman's American Journal of Science* for November, 1857 (Vol. XXIV., p. 45). In this Paper, Ritchie enumerates the causes of the difficulties met with by Stöhrer and Hearder in lengthening the secondary spark beyond three inches, and proceeds to describe his own improvements. Ritchie wound the secondary wire on a glass tube, beginning near one end and winding the wire in a sort of very steep cone (*see* Fig. 24). When this cone of wire was wound on, a *washer* or disc of vulcanised rubber was slipped on and cemented with beeswax and resin, and the end of the wire passed down and insulated with a strip of rubber, and then another cone of wire built up until the whole tube was wound full of coils, insulated from each other with washers or discs of sheet rubber. With a helix so made of 7,000ft. of wire Ritchie obtained a secondary spark of 2¼ inches, and with 30,000ft. of wire a spark of six inches. He supplied the above coils with condensers, having respectively 30 and 75ft. of coated surface, the insulator being thin sheet gutta-percha. He found that it was very important to get high insulation between the primary and the secondary coils, and that it was necessary to overlay the glass tube on which the secondary was wound with many sheets of gutta-percha tissue. In 1859 Ritchie sent to Franee, by MacCulock, a coil made in the above way, which gave secondary sparks 35 centimetres in length, which astonished the French savants, they, as Du Moncel says, not knowing nor caring to know the results of the previous work of M. Jean. A recent coil, made about 1860 by Ritchie, is figured by Du Moncel in

* It is stated in Noad's *Manual of Electricity*, Part II., that Hearder began his work on induction coils in 1846, but this is incorrect.

* See *Phil. Mag.*, Vol. XII., 4th series, 1856, pp. 377 and 443.

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his book on the Induction Apparatus of Ruhmkorff, and is shown in Fig. 25. The coil was 120 centimetres in length, and contained 52 kilograms of wire, and weighed in all 112 kilograms. The bobbin was composed of two separable portions, and, in fact, was two distinct coils. The core was a bundle of iron wires each one millimetre in diameter. The primary coil was 60 metres long, and constructed of wire five millimetres in diameter. The secondary coil was 71,200 metres, or nearly 45 miles in length, and constructed of wire ·18 millimetre in diameter. It was made of the purest copper, covered with silk, and wound in a series of flat helices of one thickness of wire, the different spirals being insulated with paraffined paper.

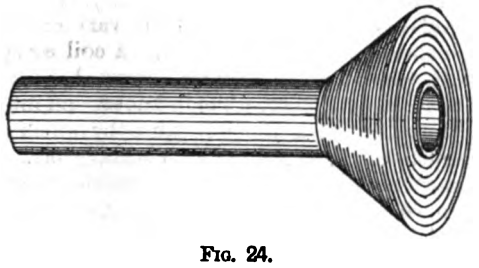


Fig. 24.

The insulation between the primary and secondary coils was separated by a glass tube, and layers of vulcanised caoutchouc placed over it. The condenser consisted of sheets of tinfoil of 30 square decimetres in area, insulated with oiled silk, and arranged so that more or less of the surface could be utilised. The interruptor was a hammer-break, actuated by an electromagnet separate from the coil. The length of each section of the bobbin was 33 centimetres, and the external diameter of the coil 22·8 centimetres. With the currents from three large bichromate cells the secondary sparks were 53 centimetres in length.

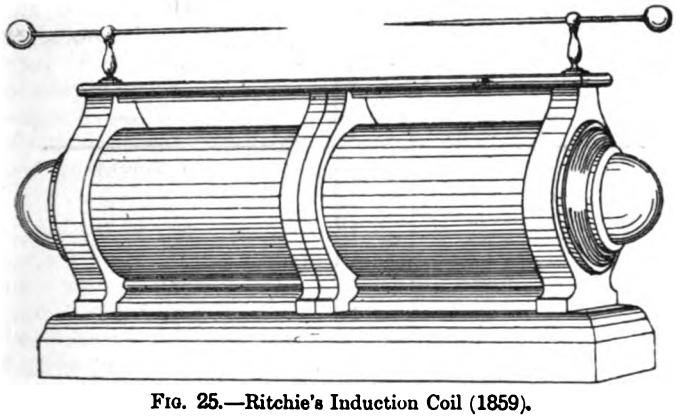


Fig. 25.—Ritchie's Induction Coil (1859).

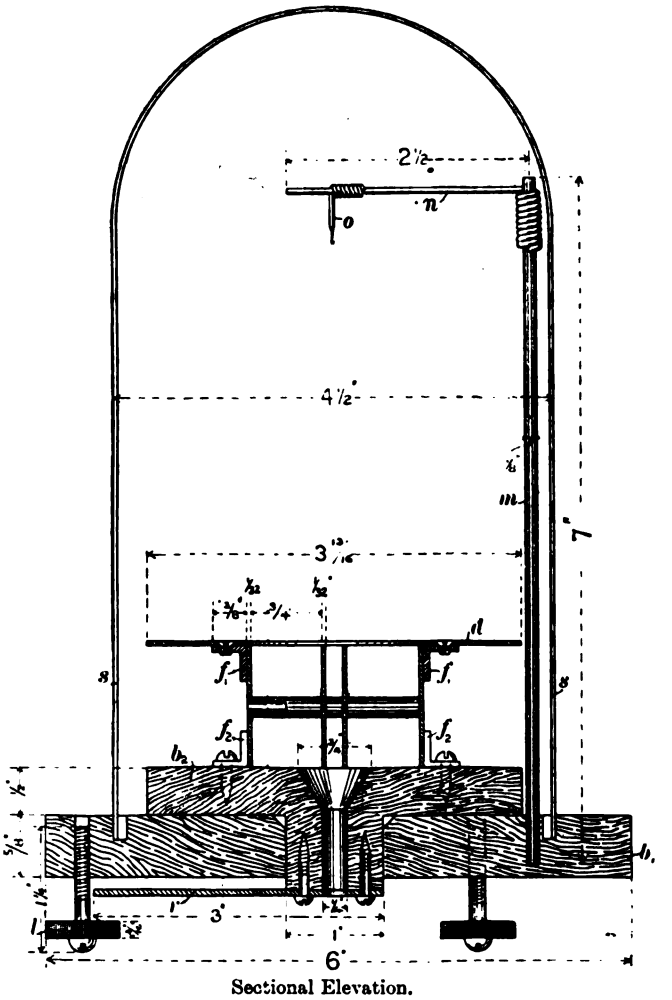
§ 19. Mr. Gassiott's Large Induction Coil.—In 1858, Ritchie constructed, to the order of Mr. John P. Gassiott, a large induction coil, which is thus described by Mr. Gassiott in the *Philosophical Magazine* for 1858 (Vol. XV., 4th series, p. 466): "The primary coil is of wire of No. 9 gauge, the helix in three layers and 15in. in length, taking altogether 150ft. of wire. The iron core is 18in. in length and about 1¾in. in diameter, of annealed iron wires, No. 16 gauge, annealed with the very greatest care, having been a fortnight in cooling. The primary wire has a cover of gutta-percha, one-tenth of an inch in thickness; over this a glass tube. The secondary helix is divided into three bundles, each five inches in length, wound on cylinders of gutta-percha, the total length of secondary wire being 73,650ft., or 14 miles." The secondary wire was insulated and wound vertically, that is, in separate flat helices. The condenser consisted of varnished tissue paper, three layers of each sheet between every sheet of tinfoil, and there were three condensers which could be employed, of 50, 100, and 150 square feet of coated surface respectively. The coil would give 12½in. sparks. The interruptor was a ratchet break worked by hand, which enabled various rates of interruption to be applied. This coil was used by Mr. Gassiott in his researches on electrical discharge in vacuo, and gave very fine effects.

(To be continued.)

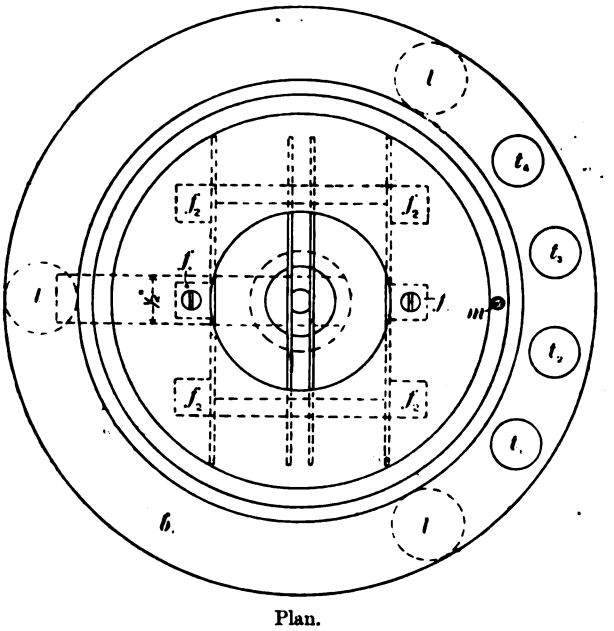
ELECTRICAL INSTRUMENT MAKING.—III.

SUSPENDED NEEDLE GALVANOMETER.

The galvanometer to be described in the present article will be of use in many cases where the extreme delicacy of a reflecting galvanometer is not required, but a mirror may be employed with this instrument in some cases, such as balance tests with a zero method.



Sectional Elevation.



Plan.

Fig. 1.

The base of this instrument is in two parts; the lower part, *b*, is 6in. in diameter and ⅝in. thick; there is a hole through

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its centre 1in. in diameter; around this is a concentric groove, into which the glass shade, *s*, of the instrument fits. This groove must be capable of taking a shade 4½in. in external diameter, but should be made wide (⅛in.), so that a smaller shade may be used in case this size is not to be readily procured. If the shade is a loose fit, a few little pieces of wash-leather should be fixed round its edge. The groove should be about ¼in. deep. On the underside of the base b_1 are three levelling screws, *l*, l_1, *l*. These consist simply of 1¼ No. 12 brass screws, with flanges $\frac{3}{16}$in. thick and 1in. to 1¼in. diameter, soldered to them close up to the heads; the rims of these flanges should be milled. The slots in the screwheads should be filled up with solder, and the screwheads smoothed up with fine emery paper. The coils of the instrument are carried on a revolving base b_2; this is shown 3$\frac{3}{16}$in. diameter and ½in. thick. On its underside is a central projection, 1in. in diameter and ⅜in. deep, which passes through the central hole in b_1; great care must be taken in making these fit well; b_2 should be able to turn sweetly and easily in b_1, but at the same time there should be no side-play, the rubbing surfaces of both b_1 and b_2 should be made quite smooth with

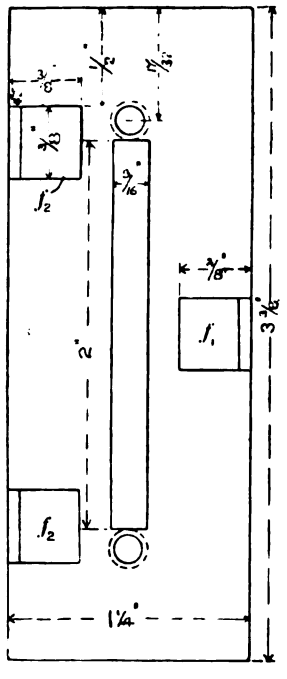

Fig. 2.

fine glass-paper, and before the instrument is finally put together, they should be rubbed with plumbago, and *not* varnished. The exposed surface of the wood should, of course, be varnished or French polished, not so much for the sake of appearance as for enabling it to be kept clean. Through the centre of b_2 is a funnel-shaped hole, through which the connections pass to the terminals *t*; screwed on to the bottom of the projecting centre of b_2 is a strip of brass, *r*, 3in. long, ½in. wide, and about $\frac{1}{16}$in. thick, by means of which the revolving base may be turned round without removing the shade. The bobbins for the coils of this instrument (Fig. 2) are constructed in the same manner as of the galvanometer last described. Their dimensions, however, are different, the length being 3⅜in.; height, 1¼in; width of coils inside cheeks, ¾in.; space between inner cheeks, $\frac{3}{16}$in.; width of slots, $\frac{3}{16}$in.; length of slots, 2in.; distance from centre of rivetting wire to end of cheek, $\frac{19}{32}$in. There are six lugs, similar to those described in the preceding article; the two top ones, f_1, hold the dial d_1, while the coils are fixed to b_2 by means of the four lower lugs f_2, the holding being effected by means of ½in. No. 6 round-headed screws. The dial of this instrument is also similar to that of the pivoted galvanometer (*The Electrician*, June 26th), its outer diameter being 3$\frac{13}{16}$in., and that of the central opening 1$\frac{13}{16}$in. The four ends of the coils should be soldered to four pieces of flexible wire cord, which should pass through the central hole in b_2. The joints, after having been carefully insulated, should be pulled into the wide part of the hole, and the flexible cords, where they come out from the opposite end of the hole, should be firmly wedged in position (so that they cannot possibly twist when b_2 is turned round). Their other ends are connected to the terminals. The ends of one coil should be connected to terminals t_1 and t_3, and the ends of the other to terminals t_2 and t_4, so that when terminals t_2 and t_3 are joined across, the two coils will act together in series, and when t_1 t_2 and t_3 t_4 are joined across respectively the coils will be acting together in parallel.

The gibbet for the suspension of the needle system may be constructed in the following homely fashion:—A piece of No. 9 S.W.G. brass wire, *m*, is straightened and fixed vertically in b_1. A piece of No. 16 S.W.G. brass wire *n*, 2½in. of which is made quite straight, is coiled into a spiral of eight or ten convolutions, which slides fairly tight upon *m*. A similar spiral, *o*, of No. 18 S.W.G. wire which slides tight upon *n* is about ⅜in. long, and is filed to a long fine point, which is bent round into the form of a hook; into this hook the silk fibre by which the needle system is suspended; is cemented with sealing-wax. It will be seen at a glance that this arrangement enables the position of the needle to be adjusted in any direction, vertically or horizontally.

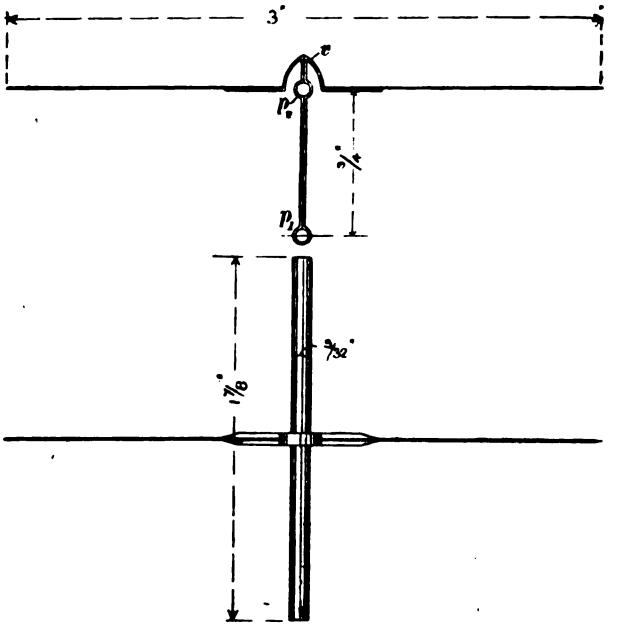

Fig. 3.

The needle system has two needles of round steel, $\frac{3}{32}$in. in diameter by 1$\frac{7}{8}$in. long; these are suspended in a stirrup made as shown in Fig. 3. A piece of very thin brass or copper strip, 3in. long and ⅛in. wide, is doubled to form a circular loop, p_1; this is to hold the lower needle. The two sides are then whipped together with silk for a distance of about ⅝in., when they again separate and form a loop, p^2, through which the upper needle is to pass. The centres of the two loops should be ¾in. apart. The two ends of the strip are whipped together again for about $\frac{3}{16}$in., when they separate, being bent downwards and outwards on opposite sides of the needle, as shown in Fig. 3. To the wings thus formed pointers of glass should be fixed with sealing-wax. Glass tube may be drawn down very fine by heating it to redness over a spirit lamp, and pulling the ends sharply apart. With a little practice, very fine and straight pointers may be made in this way. The ends of the pointers should be dipped into ink, which will flow up into them owing to capillary action. The pointers must be, of course, set exactly at right angles to the needles, a bit of fine brass or copper wire is passed under the wings at *r*, and is twisted into a hook; to this the silk fibre is fixed with sealing-wax.

To suspend the needle system, place two drops of sealing-wax on a piece of white paper about 8in. apart. Then persuade one end of a piece of single silk cocoon fibre to rest on one of the drops of wax, and as soon as it does so touch it with a hot wire to make the sealing-wax stick to it. The fibre should then be

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stretched over the other drop of sealing-wax and stuck to it in the same manner. The silk should be a little slack when the paper is flat. The hook *o*, having been previously armed with a minute drop of sealing-wax, is hooked on to the silk fibre in such a manner that the fibre passes round it twice; it is then touched with the hot wire so as to fix the fibre. The hook of the needle system is fixed in the same manner, at a point about 4in. from *o*. The outer ends of the fibre are then cut away close to the hooks, and the whole hung up by the needle system, so that hook *o* is capable of turning freely. It should be left in this position for a day or so, in order that the twist may be taken out of the fibre. The needle system may then be placed within the coils of the galvanometer, and the spiral *o* slipped on to *n*, which has previously been lowered. The arm *n* should only be raised when the instrument is in use.

THE FRANKFORT EXHIBITION.—V.

(FROM OUR SPECIAL CORRESPONDENT.)

In the hall allotted to scientific and surgical apparatus Siemens and Halske occupy a large space, and have set up a laboratory where the instruments are shown in use. Here are to be seen all the well-known measuring instruments for which the firm is renowned. Amongst the exhibits attention may be called to a modification of Thomson's double bridge, enabling one to measure resistances from a tenth of an ohm to a microhm. The laboratory apparatus includes a selenium-photometer, and an electric pyrometer, for measuring temperatures up to 800°C.

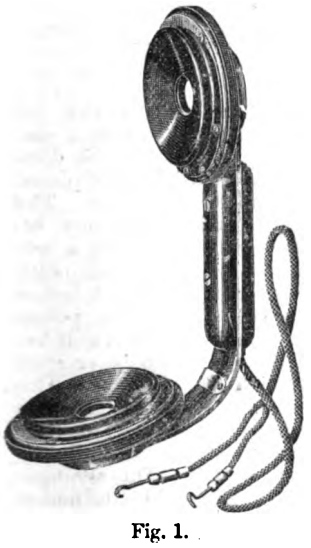

Fig. 1.

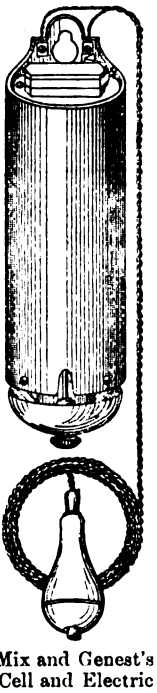

FIG. 3.—Mix and Genest's combined Dry Cell and Electric Bell.

In the Telegraph and Telephone Hall the firm of Mix and Genest, of Berlin, have an interesting collection. The most prominent object is their multiple switchboard for 6,000 subscribers. A practical idea which has been well carried out by this firm is their portable telephone, consisting of a spoon-shaped telephone and a microphone in one instrument, united by a handle (Fig. 1). The apparatus is provided with an ornamental stand for office and indoor work, and an oak case for work in the field, &c. (Fig. 2). The instrument is well adapted for military purposes. The case comprises a microtelephone with lever for closing the microphone battery, the induction coil of the microphone in connection with a "Neef" hammer serving to produce alternating currents of sufficient strength to call up the telephone at the far end, and two small dry cells. Another compact device exhibited by Messrs. Mix and Genest is a combined dry cell (Klingel) and electric bell (Fig. 3).

Work on the line for the electric transmission of power from Lauffen, on the Neckar, to Frankfort is in full swing, and a number of workmen are busy, under the instructions of the German Post Office and the Wurtemburg telegraph officials, in erecting the posts, fixing the insulators, and running the wire. This work, as well as that of installing the machines, will be completed by the middle of August. The Imperial Chancellor

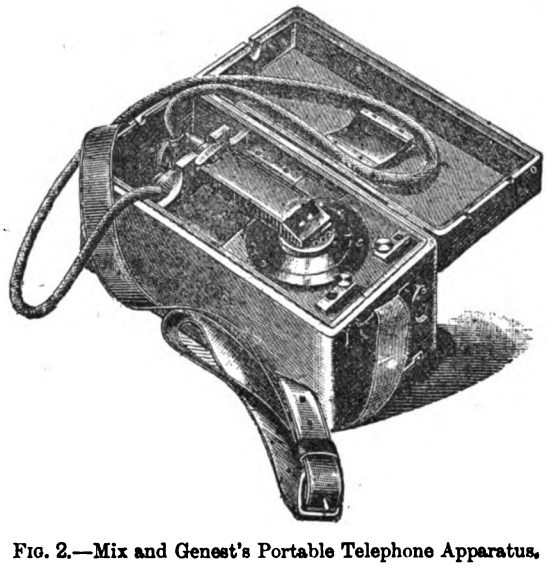

FIG. 2.—Mix and Genest's Portable Telephone Apparatus.

has appointed Prof. von Helmholtz, President of the Committee, to watch and report on this undertaking, which Committee consists of Drs. Löwenherz, Lummer, and Brodhun. Profs. Dietrich (Stuttgart) and Weber (Zurich) are also to report on the work for their respective Governments.

THE ELECTRIC TRANSMISSION OF POWER.*

BY GISBERT KAPP.

LECTURE II.—*Fundamental Principles.*

(Continued from page 310.)

The fundamental principle on which the electric transmission of power depends is that peculiar, and, I might almost say, mysterious interaction between magnets and currents, which we comprise under the name electro-magnetic induction; but more particularly two special cases of electro-magnetic induction, the one discovered by Oersted and the other by Faraday. Oersted discovered that, under certain conditions, a compass needle is deflected by an electric current, and Faraday discovered that relative motion between a magnet and a magnet and a closed conductor will, under certain conditions, produce a current of short duration in the conductor. Oersted's effect is a permanent one; the needle remains deflected as long as the current flows. Faraday's effect is transient; the current flows, not as long as the magnet is present, but only during the time that it takes to change the relative position of magnet and closed conductor.

It is clear that in Oersted's experiment the movement of the needle is due to the action of a mechanical force between the magnet and the coil. In Faraday's experiment the transient current must be caused by a transient electromotive force, and this, in its turn, is caused by the relative movement between the coil and magnet. The modern method of explaining these things is based on the conception of magnetic lines of force, and the looping of these lines with the wire coil through which the current flows. The whole subject has been so admirably laid before this Society in the Cantor Lectures on the Dynamo, which Prof. S. P. Thompson delivered here in 1882, that I need not occupy time by going over the same ground again, but may take it for granted that you are familiar with the lines of force theory. In modern language, we

* Cantor Lectures delivered before the Society of Arts, February, 1891

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may therefore explain the two fundamental phenomena somewhat as follows :—

1. The looping of a current with magnetic lines of force sets up a mechanical force between the conductor and magnet (or its equivalent).

2. Relative movement between a magnet (or its equivalent) and a wire coil sets up in the latter an electromotive force.

It follows immediately from these two propositions that looping and movement combined will require the expenditure of power, or yield power, accordingly as the movement is opposed to, or in the direction of, the mechanical force produced by the looping. In other words, that we can, by these simple means, convert mechanical into electrical power, or electrical into mechanical power. If we carry out both processes at the same time, that is, if we combine Faraday's with Oersted's experiment, we require, of course, a pair of wires between the two converting instruments. In Faraday's experiment, if we thrust the steel magnet into the wire coil, we expend mechanical power, which is converted into the electrical power represented by a current flowing under a certain, though in this case very small, potential difference. The power represented by

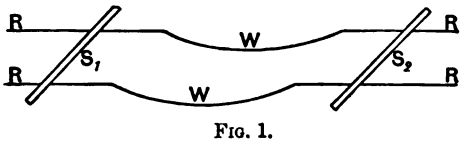

FIG. 1.

this current is again reconverted in Oersted's experiment into mechanical power, which is used to produce the deflection of the magnet. The total amount of power thus transmitted from one place to another is, of course, exceedingly small, but the same principle, applied on a larger scale, effects the transmission of many horse-powers, and it will be my task to show you how this is done in practice.

Before entering upon this subject, I must explain an expression used in stating the fundamental principles on which the electric transmission of power is based. I said that we require a coil and a magnet "or its equivalent." The equivalent of a magnet is, as you know, a coil through which a current flows, and the experiments ought, therefore, also to succeed if instead of the magnet we use such a coil. In practical work we use neither a steel magnet nor a coil alone, but a combination of a coil with an iron core, constituting what is known as an electro-magnet.

You know that, according to our modern conception of magnetic fields, there emanates from each pole of a magnet a certain flow of lines of force ; and when we thrust a magnet into a coil we cause the individual wires of the coil to cut through the lines of force. The quicker the movement, that is to say, the more lines of force are cut by each wire in unit time, the greater is the E.M.F. produced ; and the more wires are contained in the coil, the greater is the E.M.F. produced, since the E.M.F. impulses of the different

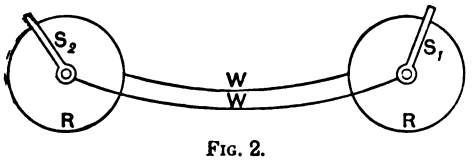

FIG. 2.

convolutions are added. It is also easily seen by experiment that the stronger the magnet the greater will be the E.M.F. ; so that we find that the E.M.F. is proportional to the product of strength of field, speed of cutting, and length of conductor. Denoting these quantities respectively by H, v, and l, the E.M.F. produced is in C.G.S. units $H\ v\ l$, and remembering that a hundred million C.G.S. units of E.M.F. are equivalent to one volt, we have the E.M.F. in volts given by the expression

$$\text{Volts} = H\ v\ l\ 10^{-8}.$$

In this formula the strength of field is given in lines per square centimetre, and speed and length are given in centimetres.

The mechanical force experienced by a conductor in the neighbourhood of a magnet pole is, according to our modern views, due to the fact that the conductor is laid across the lines of force emanating from the magnet pole. The force in dynes is given by the product, $H\ c\ l$, c being the current. Since there are 981,000 dynes required to represent the force of one kilogramme, and since the C.-G.-S. unit of current is 10 amperes, we have the force produced by a current of c amperes—

$$\text{Kilogrammes} = \frac{H\ c\ l}{9{,}810{,}000}.$$

These are the two fundamental equations required in the design of plant for the electric transmission of power. Now let us see what is the most simple kind of plant we could possibly employ. At the generating station we require a conductor cutting lines of force ; this conductor must be joined by wires with a similar conductor at the receiving station. The second conductor is also laid across lines of force, so that when a current passes it will be acted upon by a mechanical force displacing it parallel to itself and doing work. The arrangement here described is shown in Fig. 1, where the lines R represent fixed, horizontal, parallel rails, across which are laid sliding rails or sliders, S_1, S_2. Imagine the magnetic lines of force passing vertically between the fixed rails, then, if we displace the slider S_1, an electromotive force will be set up in it, causing a current to flow through the connecting wires, W, and the slider S_2 at the receiving station. The slider S_2 is supposed to be laid across lines of force, and will, therefore, be acted upon by a mechanical force. Thus, power may be electrically transmitted from the slider S_1 to the slider S_2. It will immediately occur to you that the experiment I have here illustrated could easily be tried by means of any railway. The fixed conductors and connecting wires would be the rails ; the generating slider would be a crowbar thrown across them, and hauled along by a train ; and the lines of force would be supplied by the vertical component of terrestrial magnetism. At another part of the railway— possibly miles away —another crowbar thrown across the rails should then be set in motion, by the current passing through it. Theoretically, such an arrangement represents correctly enough the electric transmission of power ; but I need hardly tell you that it would not work in practice. If you apply the E.M.F. formula I have given to this case, you will find that, even if the slider is hauled along at the speed of an express train, there will only be generated about the one-thousandth part of a volt, the reason being that the magnetic field provided for us by nature is so extremely weak. If we could apply an artificial magnetic field of the strength generally employed in dynamo machines—that is, about 10,000 times as strong as the vertical component of terrestrial magnetism—then we could get

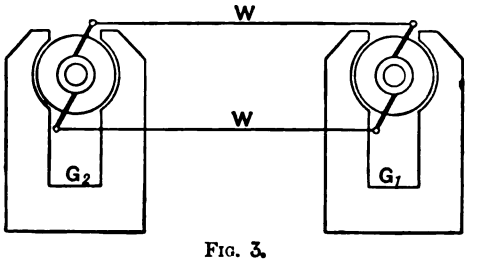

FIG. 3.

about 10 volts in our slider. Now, it is obvious that we cannot spread so strong a field over miles of railway ; and we must, therefore, alter our arrangement. This may be done as indicated in Fig. 2, where one of the rails has been replaced by a centre contact, and the other by a circular conductor. The slider, instead of being moved parallel to itself, must now revolve round the centre contact, which can easily be done by a belt and pulley. We have thus arrived at what is known as a non-polar dynamo. But even this arrangement, although very much better than the progressive slider, is not of practical value for power transmission, because the E.M.F. of non-polar dynamos is still too low. It is only a few volts, whereas we require hundreds, or even thousands, of volts to carry the current to any distance. The obvious remedy is to use a large number of revolving sliders, so connected that the E.M.F. generated in each shall be added ; in other words, instead of a non-polar dynamo, we must use an ordinary continuous current dynamo, wound for high E.M.F. This arrangement is shown in Fig. 3, where G_1 is the generator and G_2 the motor or receiving dynamo. If you connect their brushes, as shown in the diagram, and rotate the armature of the generator, a current flows through it, the line wires W, and through the armature of the motor, and exerts upon the latter a mechanical force, tending to produce rotation and give off mechanical power. I am able to show you this experimentally, by means of two dynamos connected, as shown in Fig. 3.

The Machines Employed in Power Transmission.

This experiment has shown how power may be transmitted electrically. Let us now consider somewhat more in detail the different parts of the transmitting plant. At one end of the line of transmission we have the generating dynamo, at the other we have the motor dynamo, and then we have the line itself, consisting of two wires insulated from each other and from earth. You will readily see that although for the convenience of experimental illustration I have placed the generator and motor close together, this proximity was not an essential condition of the experiment. The motor might have been placed in another room, or in a different part of London, and still the experiment would have succeeded, provided I had used sufficiently stout and well-insulated connecting wires. But then you could not have had

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ocular demonstration of the fact that movement of the generator armature is closely followed by a corresponding movement of the motor armature.

A full treatment of my subject would, of course, include a complete investigation of the dynamo, but this I shall not attempt. In the first place there is no time for it, and in the second place it is hardly necessary, since you are all more or less acquainted with these machines. I shall, therefore, not occupy time by giving mathematical proofs for the few formulæ I shall have to use, but assume that they are familiar to you. They are as follows :—

$$\text{Volts} \ldots\ldots \ldots = H\,v\,l\,10^{-8}$$
$$\text{Kilogrammes} \ldots = H\,c\,l$$
$$\overline{9{,}810{,}000}$$

C Total current through armature ; c, current through single armature conductor.

e_a E.M.F. in armature in volts.

τ Number of active conductors counted all round armature.

p Number of pairs of poles ($p=1$ in a two-pole machine).

n Speed in revolutions per minute.

F Total induction in C.-G.-S. lines.

Z ,, ,, English lines.

Electromotive force

$$e_a = F\tau\frac{n}{60}10^{-8}$$
$$e_a = Z\tau n\,10^{-6}$$

for two-pole machines.

$$e_a = pF\tau\frac{n}{60}10^{-1}$$
$$e_a = pZ\tau n\,10^{-6}$$

for multipolar machines with series-wound armature.

Torque.....

Kilogramme-metres $= 1{\cdot}615\,F\tau C\,10^{-10}$
Foot-pounds $= 7{\cdot}05\,Z\tau C\,10^{-6}$

for two-pole machines.

Kilogramme-metres $= 3{\cdot}23\,F\tau cp10^{-10}$
Foot-pounds $= 14{\cdot}10\,Z\tau cp10^{-6}$

for multipolar machines.

In analysing these formulæ you will observe a curious parallelism. The symbols for field strength and total number of active armature wires occur in either group, but the current occurs only in the group giving torque, or mechanical turning effort, and the speed occurs only in the group giving E.M.F. Now, if you multiply any of the torque formulæ with the speed you get on the left—mechanical power ; and on the right the product of electromotive force, multiplied with current and a constant, or, in other words, electrical power ; by working this out in figures, you will find that mechanical energy expressed in horse-power is equal to watts divided by 746, the well-known equation for converting mechanical into electric power.

The formulæ are equally applicable to cylinder armatures wound gramme fashion and to drum armatures, provided we count not turns of wire but active conductors over the whole circumference of the armature. As regards two-pole machines, the formulæ are the same as found in every text-book on dynamos, but as regards multipolar machines, a little explanation is required, both as to the winding and as to the advantage or otherwise of using more than one pair of poles. To make the explanation clear, I must refer for a moment to the ordinary method of drum winding for two-pole armatures. When such a winding is illustrated in a text-book, the author takes care to show only very few conductors, for the simple reason that the diagram would be one unintelligible maze of lines if it were drawn so as to represent an armature as really made. To get over this difficulty I employ, instead of a diagram, a tabular statement of the winding such as you see on the wall. This particular table represents the winding of a drum armature having 100 active conductors.

Drum Winding.

F	B	F	B	F	B	F	B	F	B	F
D	U	D	U	D	U	D	U	D	U	
100	49	− 98	47	96	45	94	43	92	41	
90	39	88	37	86	35	84	33	82	31	
80	29	78	27	76	25	74	23	72	21	
70	19	68	17	66	15	64	13	62	11	
60	9	58	7	56	5	54	3	52	1	
50	99	+ 48	97	46	95	44	93	42	91	
40	89	38	87	36	85	34	83	32	81	
30	79	28	77	26	75	24	73	22	71	
20	69	18	67	16	55	14	63	12	61	
10	59	8	57	6	55	4	53	2	51	
100	49	− 98								

The figures at the top of the vertical columns indicate the direction of winding, supposing the winder looks at the armature end on. The letter D signifies a wire, wound down or away from him ; and the letter U a wire wound up or towards him. The letters F and B, placed between the others, denote the front and back connections respectively. In modern machines these connections are not made of flexible wire, but are separate pieces, specially made to shape, and are generally of larger section than the conductor, so as to reduce the resistance of the armature as much as possible. One form of connector is on the table, both in pieces and built up. By referring to the winding-table, you will see that every wire is numbered ; and thus we can see at a glance how the ends of each wire are connected. The table on the wall refers to a two-pole machine, that on the slip in your hands to an eight-pole machine, wound so as to obtain the E.M.F. of the four pairs of poles in series. The printed table, giving the eight-pole winding, is almost self-explanatory ; but, to assist you in understanding the winding of these multipolar machines generally, I had this model prepared, showing a few of the conductors of a six-pole armature. This method of winding has been invented by Messrs. Scott and Paris, patents 4,683 and 6,261 of 1874. There are no internal cross-connections, the ends of the conductors being joined simply by connecting segments of the kind I have just shown you ; but with this difference, that each segment, instead of embracing half a circle, embraces only one-sixth of a circle. The winding goes in zig-zag, so to speak, round the armature, returning to the second wire in front or behind the previous starting-point. There are thus only two brushes required. The winding tables show, also, very clearly how the E.M.F. increases from wire to wire, and that the greatest difference of potential occurs between neighbouring wires at the diameter of commutation. The difference of potential between neighbouring connector segments is, however, limited to the E.M.F. due to the two conductors. The winding is used for machines intended to give high-pressure currents, such as are required in power transmission. When low-pressure and large currents are required, the winding is altered, so as to form overlapping loops on the armature, and for intermediate electromotive forces a combination of both methods can be used. But as these windings have no immediate importance for power-transmission, I shall not detain you with a description of them.

Table *of Winding for 8-pole Drum Armature ; 202 Conductors ; Series Winding ; Brushes* (+) *135° apart.*

F	B	F	B	F	B	F	B	F
D	U	D	U	D	U	D	U	
202	25	50	75	100	125	150	175	
200	23	48	73	98	123	148	173	
198	21	46	71	96	121	146	171	
196	19	− 44	69	94	119	144	169	
194	17	42	67	92	117	142	167	
192	15	40	65	90	115	140	165	
190	13	38	63	88	113	138	163	
188	11	36	61	86	111	136	161	
186	9	34	59	84	109	134	159	
184	7	32	57	82	107	132	157	
182	5	30	55	80	105	130	155	
180	3	28	53	78	103	128	153	
178	1	26	51	76	101	126	151	
176	201	24	49	74	99	124	149	
174	199	22	47	72	97	122	147	
172	197	20	45	70	95	+ 120	145	
170	195	18	43	68	93	118	143	
168	193	16	41	66	91	116	141	
166	191	14	39	64	89	114	139	
164	189	12	37	62	87	112	137	
162	187	10	35	60	85	110	135	
160	185	8	33	58	83	108	133	
158	183	6	31	56	81	106	131	
156	181	4	29	54	79	104	129	
154	179	2	27	52	77	102	127	
152	177	202						

Now, as to the advantage of multipolar machines, such as the one which I illustrated on the screen. The field magnets are arranged perfectly symmetrical round the armature ; and thus the one-sided magnetic pull, consequent upon the employment of a single pair of horse-shoe magnets, is avoided. There is very little magnetic leakage, the machine being what is known as iron-clad ; and, as I have already shown, the E.M.F. is equivalent to that of several smaller machines, coupled in series. The internal diameter of the armature is very large, affording plenty of space for the ingress and egress of air ; and the weight of the machine is less than that of an equivalent two-pole machine. The most important advantage, however, is the

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small armature reaction. Experience with large two-pole machines has shown that there is a limit to the size above which such machines are satisfactory. This limit depends, of course, on the speed and voltage, as well as on the output; but, roughly speaking, we may take it that, for moderately high voltage, and an output above 100 H.P., the multipolar machine is preferable; and we find, accordingly, that, for the transmission of large powers, multipolar machines are, as a rule, employed.

I have hitherto not made any distinction between motors and generators, because the difference between them is almost negligible. There are certain secondary effects which may be a little greater in one machine than in the other; but these are of so little importance that it will not be worth while to devote any time to their consideration. As a rule, a good generator makes a good motor. All we require to do is to set the brushes a little forward of the neutral line in the former, and a little back from that line in the latter. Now let us see what it is we must naturally aim at in putting up a transmission plant. At the generating end of the line we want as high an E.M.F. as we can get, because a high E.M.F. means large power and small percentage loss due to line resistance. At the motor end we want as large a torque or statical effort as possible, combined with a certain speed. But a glance at the formulæ will show that it is impossible to get speed without also getting E.M.F., which, in the case of the motor, must oppose the current, and thus the current actually flowing through the motor is that due to the difference between the E.M.F. of the generator and the counter E.M F. of the motor. This difference, divided by the total resistance of the circuit, gives the current.

The electrical power developed in the generator is the product of this current, and the E.M.F. in its armature. The electrical power converted by the motor is the product of the same current and the counter E.M.F. of its armature. It therefore follows that the electrical efficiency of the whole system is given by the ratio between the generator and motor E.M.F. The more nearly alike these two are, that is to say, the less E.M.F. lost in resistance, the greater will be the electric efficiency. Now, the smaller the current the less E.M.F. is lost in resistance; but to get power with a small current we must work at high pressure, and we thus find that, from the point of view of electrical efficiency only, the higher the voltage the better. There are, however, other things to be considered besides electrical efficiency, and if we take due account of these we find that for every case there is one particular voltage at which it is best to work.

Upon this subject I shall enter presently, but, before doing so, I must place before you some points in connection with the regulation of speed and power in transmission plants. Unless we can control the speed, and regulate the power given out at the receiving end of the line, the most perfect motor or the most efficient system is useless. Fortunately, however, electricity is not only a powerful transmitting agent, but also one that can be easily controlled, and my next task is to show you how this control is effected.

(To be continued.)

THE INCANDESCENT LAMP INDUSTRY.*

BY FRANK GÉRALDY.

The Chamber of Deputies, during the sitting of July 6th, voted a duty of 500 francs per 100 kilogrammes on all incandescent lamps entering France. M. Georges Berger spoke vigorously in favour of this tax being still higher, and he has been reproached both for his speech and for his vote. M. Berger has taken up the position of freetrader; he is president of the League for Defending Raw Materials. There was, therefore, something inconsistent on his part in demanding protection. This is true enough, but what will you? M. Berger has only acted in the same way as have several of his colleagues placed in the same situation, who have imitated La Fontaine's dog, which unable to protect his master's dinner resigned himself to eating his share. They saw very plainly that the Chamber was bent on ultra-protection, and although combating this bad policy they were afraid lest they should be betrayed into leaving their constituents unprotected in the midst of universal protection. I do not know if this was tactically good. Many industries which rely implicitly on protection will be greatly disillusioned when they come to enjoy it. It would perhaps have been better to have adhered to one's principles. The incandescent lamp industry in particular will, I think, gain but little by the duty just voted.

The incandescent lamp market has altered enormously during the last four years. Lamps were then commonly quoted at 5 francs, 4 francs and 4 francs 50 centimes being considered as reduced prices. It was felt that a reduction was sure to come, but it was not foreseen that it would come so quickly, and that it would be so large. To-day, incandescent lamps can be had for 2 francs 50 centimes, or 2 francs, and even less.

* From *La Lumière Électrique.*

Labour, as we know, enters largely into the manufacture of an incandescent lamp, and it was natural that the industry should at first take root in countries where labour was cheap, and the electrical industry, at the same time, sufficiently developed. Such countries were Germany and the neighbouring States. But once the reduction had begun, once it was seen that it was possible to manufacture more cheaply, it was pretty certain that France would take the field; and there are to-day French firms with a large turnout which are doing well, and which are not beaten by foreign producers. Hence, following the well-known law, prices no longer depend on external, but on internal, competition. Since the firms in question have succeeded in competing with the foreigner, it is evident that the cost of production is not sensibly higher than it is abroad. Moreover, cheapness is not everything; the quality of a lamp is naturally not without importance. Among the very cheap foreign lamps which flooded the market there were inferior ones, short lived, and burning with irregular brightness. People soon got disgusted, and took to lamps somewhat dearer, but much superior.

This seems to me to be the key of the position. It is impossible to return to former prices; they are low and will remain so. The protection granted amounts to about ·175fr. per lamp, and will not, I think, be sufficient to exclude foreign lamps. If it does succeed in doing so, French lamps will multiply, and home competition will bring down prices to the same level, because, after all is said and done, it is a possible price, and one which a large, well-organised industry should be contented with. The key to success will be the quality of the produc-. By quality I mean the general properties of a lamp, regular voltage, whiteness of light, long life, ease of fixing, strong construction, and other like essentials. Other more special qualities, such as satisfy the taste and requirements of the consumer, have to be aimed at. The public, indeed, has begun to have some taste in electric lighting matters. Only a little time ago it accepted all that was given it; great choice was not, indeed, then possible; to-day the public has seen, compared, and has its preferences. Certain styles of lamp, certain arrangements of filament, are in request. In Paris, at the present moment, fashion seems to favour looped filaments, and the look of the simple horse-shoe shape is considered cold. Lamps, the filaments of which are closely coiled, emitting light from a more restricted centre, and appearing more brilliant, are preferred, and, generally speaking, small-sized lamps are wanted.

Taste is also changing with regard to candle-power. Ten candle-power lamps were at first almost the only type asked for, because one such lamp naturally replaced a gas burner. Now people are beginning to take lamps of 16 c.p., and more, which is a good thing, because these lamps are in reality better and more efficient than the smaller units. The art of manufacture should be sufficiently flexible to be able to lend itself not only to meeting the present demands of the public, but probable developments. Future requirements, I repeat, ought to be foreseen.

Up till now all improvements in lamps (but few in number, by-the-way) have only had for object increased strength and durability, and but little attention has been given to the lamp as a piece of machinery, that is to say, to its consumption of energy. All 10 c.p. lamps are from this point of view much the same, and consume about 4 watts per candle. I do not overlook the statements of many manufacturers that they have attained better results, and, as a matter of fact, when it is a question of a few lamps, one can obtain without much difficulty lamps which take 3·5 watts, and even less (I am talking of 100-volt lamps), but if we take a large supply we revert to the 4 watts indicated above. The fact is, lamp makers have not as yet succeeded in reducing the energy consumed without at the same time shortening the life; an important factor, owing to the high price of the lamp, and the manufacturer has been afraid to displease the consumer by sacrificing durability. But the simplest calculation shows that, taking into consideration the usual price of electricity in Paris (the light and cost being the same), a lamp taking, for example, 30 watts, and lasting 500 hours, would be appreciably more economical than one taking 40 watts, and burning 1,000 hours. It is somewhat difficult, it is true, to make good 10 c.p. lamps, running at 100 volts and taking 30 watts, even with short life; the economy that it has been found possible to effect up to the present is the least possible, and it is to be feared that it has not been apparent enough to be appreciated by the consumer. It must be admitted that the supply companies have not up to the present pushed the matter. As they supply energy by meter, it would seem as if they had no interest in doing so, and that so far as they are concerned it would be better to use lamps consuming much more current. If this idea is traced to its origin, and found to have any weight, it is not to be doubted that after some time the intelligent interest of the company will be found to be identical with that of the consumer. After all is said and done, it is the consumer who has to be satisfied, and this object will be attained by giving him more light at less cost. The need for light, like other wants, is not limited. At any rate, with all our methods of lighting, we are very far from equalling the

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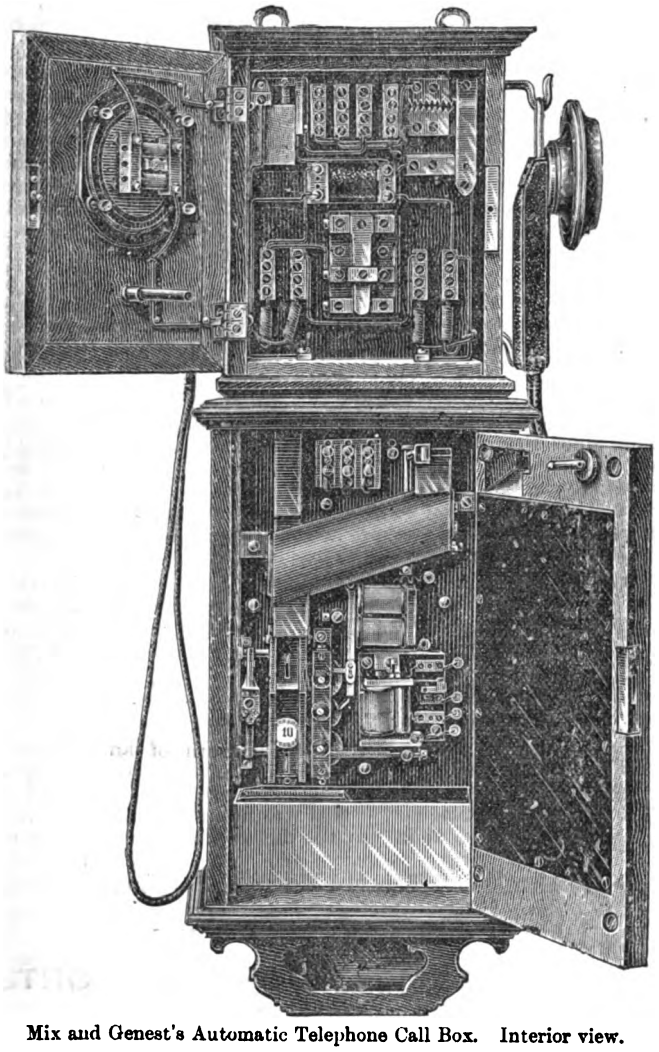
brightness of daytime which might be assigned as a limit. The more we give, the more will be taken. Supply companies need not fear, therefore, to see their receipts diminish if more efficient lamps are used. On the contrary, it is almost certain that they have in this a good way of increasing their revenue. In any case, it is one of the chief conditions of superiority for a lamp maker. I do not ignore the practical difficulties to be encountered, but they are by no means insuperable, and I am of opinion that in the present state of the market success is to be attained in this way.

THE MIX AND GENEST AUTOMATIC TELEPHONE CALL BOX.

The idea of an automatic telephone call box on the "nickel in the slot" principle is a very fascinating one to the playful public and ingenious inventor, and no doubt if a cheap and reliable instrument were forthcoming, and the inertia of the telephone interests



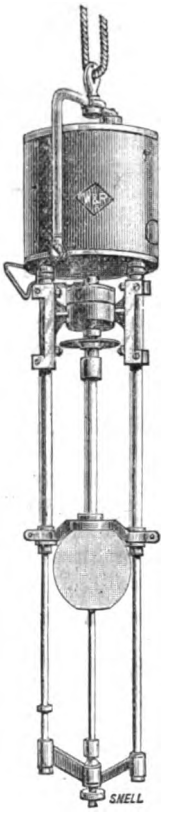
Mix and Genest's Automatic Telephone Call Box. Interior view.

could be overcome, there would be a large field for such a contrivance. At present, the same heavy annual rental has to be paid by a subscriber who only uses his telephone once or twice a day and by a stockbroker whose daily "calls" are incessant. A more equitable, and, probably, a more profitable system to the Companies would be to make a small annual charge for each telephone installed, and to tax each conversation. By this means a larger, but less talkative and discontented, *clientèle* would be obtained; and if the automatic principle were employed, a book-keeping staff of impossible dimensions would not be required.

The well-known firm of Mix and Genest, of Berlin, are now having an automatic call box tested, which they claim solves the question. The internal arrangement of the apparatus is shown in the accompanying figure. Upon a coin being inserted into the slot, it passes through the usual testing arrangement. Should it fail to pass this test, it is rejected; but, if it proves satisfactory, it passes on, and rings up the exchange. If the caller is informed that the desired connection cannot be made, he has only to press a white stud, and the coin is released, and falls to the refunding box. Should, however, the required connection be made at the exchange, the current which then passes causes the coin to fall into a groove, where it remains until the signal at close of the conversation is given, when it is released by a magnet, and allowed to fall to the cash-box, pressing *en route* a lever, which breaks all contacts. Should, however, the closing signal be omitted, it is obvious that the coin will remain in what may be termed the "talking position." In order to prevent loss from this cause, a lever is provided, by means of which an armature is moved, as if electrically, upon insertion of the next coin, and the one remaining in the instrument falls to the cash-box before the other has passed through the testing arrangement.

THE MIDGET ARC LAMP

Messrs. Woodhouse and Rawson are introducing a small arc lamp which burns in a very satisfactory manner, and, if it is found that it does not need much cleaning, should be very useful for lighting shops, &c. Instead of endeavouring to simplify the mechanism, as has been done in several small arc lamps, the feed is given by clockwork, and a pendulum escapement is controlled by a pair of differential coils. The lamps can be wound for running in series or in parallel, or with alternating currents. The lower carbon holder gives the feed, and is hung by a chain, which is released by the clockwork, and passes through and is protected by side tubes, in which the rods supporting the lower carbon slide freely. The arc is struck by a short magnet



on the upper carbon holder. The lamp takes a current of 5 amperes, and requires 45 volts. The candle-power is said to be 250, but, on making inquiries, we learn that Messrs. Woodhouse and Rawson have not yet made photometric measurements. We are also informed that 11mm. cored carbons are used for the upper, and 7mm. solid for the lower, and that they last for six hours. The 45 volts recommended should give a fairly long arc, and when a clear view of the crater is thus obtained there should be no difficulty in getting one candle-power per watt in a small lamp. A feature of the Midget Arc Lamp is a globe of only 3in. diameter. The effect is good, but we are inclined to attribute a good deal to the novelty, for with ordinary 10-ampere lamps it is well known that the public think much more of a lamp if it has a 20in. globe than if a 12in. one is provided. We cannot understand why a small globe prevents "any depth of shadow," and minimises any complaint which may be urged against the inequality of the distribution of the light." The economy, light for light, over ordinary glow lamps is so great that these little arcs, which are too small to be offensive, shou'd meet with great success.

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AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *July* 18, 1891.

The Edison Lamp Case.—The event of the present week is the decision of Judge Wallace, of the United States Circuit Court, in the incandescent lamp suit. This was announced last Tuesday, and was of a character to spread consternation among the lamp manufacturers, and to surprise all but the most sanguine of Edison's supporters. It virtually amounted to a declaration that Thomas A. Edison was the real inventor of the incandescent lamp, and was entitled to protection in his rights of invention, even to the extent of monopoly. From beginning to end the case has been a singular one; Edison's moral rights were apparently much stronger than his legal ones, so that it seemed almost impossible that the patent under which suit was brought could be sustained broadly; nevertheless, it has been, though in a somewhat illogical manner. Edison unquestionably introduced the use of carbon conductors having a considerably greater resistance than any that has previously been employed for incandescent lamps. The result was an immediate change in general practice, so that all the lamps made to-day are in this respect close imitations of the Edison construction. This was not, however, the real point at issue in the suit, for, granting Edison's priority in the use of high resistance carbon filaments, the real point to be decided was, first, whether this change in practice involved patentable novelty; and, second, whether it was covered by the famous second claim on which the decision turned. In Judge Wallace's opinion, as rendered, the first question was almost neglected, the evidence being brushed aside almost as if it had not existed. The second question was answered in the affirmative, in spite of a considerable amount of evidence brought to show that at the time of the application such a construction of the claim was not contemplated. Of the usefulness of Edison's construction there is no question, but this is a very different thing from affirming its patentability under the laws. The ground apparently taken by the Judge was that, in view of the importance of Edison's work, he should be given full rights in the matter, despite the technical points that could be raised. The attack upon the patent was purely technical in its character; the defence, for the most part, general. The Sawyer-Man Company is, of course, the one [most affected] by the decision. The Thomson-Houston Company, now working under royalty to the Sawyer-Man patents, might be able to transfer its allegiance to the Edison Company without any considerable loss. The ultimate result may be to throw the manufacture of lamps either wholly into the hands of the Edison Company, or into the hands of two or three prominent manufacturers. An appeal is, of course, pending.

Electric Traction at Boston.—Several electric railways are under construction just now, and a large amount of comfort may be gained by the friends of electric traction from the contemplation of recent reports from the West End Railway of Boston, Mass. During the month of May last the electric cars on this system ran 376,321 miles, at a cost for total operating expenses of $84,163. The total expenses per mile run were 22·36 cents; the earnings per mile run, 38·43 cents, and the net earnings, 16·07 cents. The horse cars on the system ran 1,940,683 miles, at a cost for total operating expenses of $269,556; they earned per mile run, 34·22 cents, and cost for expenses per mile run, 24·62 cents; giving net earnings of 9·06 cents per mile. These are instructive figures, and are on a sufficiently large scale to be worthy of considerable confidence. The West End service covers about 18,000,000 car miles per year, and from the data just given it is evident that the change from horses to electricity is more than worth the extra expenditure for plant.

BOOKS, &c., RECEIVED.

"The Arithmetic of Electricity." By Dr. T. O'Connor Sloane. (London: E. and F. N. Spon.)

"The Arithmetic of Electrical Measurements." By W. R. P. Hobbs. New edition. (London: Thomas Murby.)

TRADE NOTES AND NOTICES.

NOW READY.—"THE ELECTRICIAN" PRIMERS (38 in all, Vol. I., 20; Vol. II., 18), in two volumes. Price per volume 2s. paper covers, 2s. 6d. cloth; post free, 2s. 2d. and 2s. 9d. respectively. Single copies, 3d.; post free, 3½d. Prospectus on application to the Publisher.

TENDERS INVITED.—It will be seen by our advertisement columns that the Southampton Harbour Board invite tenders for lighting the Royal Pier by electricity, and forproviding and fixing two electrical cranes on the Town Quay. Plans may be seen at the office of the engineer, Mr. J. G. W. Aldridge, 9, Victoria-street, London, S.W., from whom specifications and forms of tender may also be obtained. Tenders are to be delivered at the offices of the Harbour Board, Town Quay, Southampton, not later than Monday, August 24th.

———Tenders are invited, up to August 7th, for the erection of plant for the electric lighting of the town of Cuenca (Spain).

———Tenders are invited by the municipality of Zanora (Spain) for the erection and working, for a period of 25 years, of a plant for lighting the town by electricity. Tenders will be received up to August 15th, and a deposit of £100 will be required.

ADMIRALTY CONTRACT FOR ASBESTOS GOODS.—The United Asbestos Company (Limited) has, for the seventh time, secured the contract for the supply of all kinds of Asbestos goods required for use in Her Majesty's Navy, during the ensuing twelve months. The contract includes the supply of the following brands of the United Company's well-known manufactures:—"Victor" block packing (square and round), hard spun yarn packing, "Victor" metallic sheeting, tape, rings, ovals, &c., for steam, manhole, mudhole, hydraulic, and other joints; pure tape and cloth for pipe and boiler covering and other purposes; millboard and sundries.

THE ELECTRICAL ACCESSORIES COMPANY.—We are informed that this Company is now in course of reconstruction, ample capital having been provided to enable the Company to increase its manufacturing capacity.

KIRKALDY'S LIVE STEAM FEED WATER HEATERS.—Some experiments on a paddle steamer were recently recorded in the *Engineer*, which show that under certain circumstances live steam may be used with advantage for heating feed water. The use of hot feed for preventing unequal expansion is obvious, but it is not clear how any economy of fuel can be expected. The experiments, however, showed a higher boiler pressure and increased speed of the engines, while the firemen appeared to be less pressed.

THE RECHNIEWSKI DYNAMO.—Messrs. E. L. Berry, Harrison and Co., of Lyric Chambers, Whitcomb-street, W.C., have been appointed sole agents for the Rechniewski machine which obtained the only gold medal for dynamos at the Paris International Exhibition, 1889. It has been much talked of on the Continent, and is now for the first time introduced to the home trade. A pamphlet and price list has been framed for general information.

SMITH'S PATENT AIR CUSHION EAR PAD.—This handy little invention is for use with an ordinary telephone. The elastic cylindrical part of the ear pad is stretched over the mouth of an ordinary telephone receiver, so that the inflated part forms a ring. When the telephone is in use the inflated ring beds against the user's head, and forms a perfect sound chamber. These pads are 4s. per pair, and are sold by Mr. Mogridge, New Inn, Hall-street, Oxford.

COMPANIES' MEETINGS & REPORTS.

Globe Telegraph and Trust Company (Limited).

The eighteenth ordinary general meeting of the Globe Telegraph and Trust Company (Limited) was held on Tuesday, at Winchester House, Old Broad-street, under the presidency of Sir John Pender, K.C.M.G.

The SECRETARY (Mr. William Payton) having read the notice calling the meeting, and the minutes of the last general meeting, the report of the Directors was taken as read.

The CHAIRMAN: Before I ask you to pass the resolution approving of the report, I will make a statement giving you some idea of the working of the Trust during the last 12 months. During the existence of the Company the dividend on the ordinary shares has been progressive. It has never fallen below 2⅜ per cent. That was in 1887, which was the time of the fierce Atlantic competition. Since that date the dividend has been augmented to 3½ per cent. in 1888, 4⅝ per cent. in 1889, 5 per cent. in 1890, and I am pleased to say that, though we do not propose a large addition this year, still, it is an addition, as we propose to declare to-day a dividend of 5¼ per cent. This shows, as I have said, a gradual and steady increase. The average dividend paid since the commencement of the Company in 1874 is £4. 7s. 1d. per cent. on the ordinary shares and 6 per cent. on the preference shares, and these, taken in conjunction, give a uniform dividend throughout our working period of 18 years of £5.3s.6d. per cent., which would seem to show that the investment is a steady, pro-

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gressive, and good one. The Company's holding in the Eastern Telegraph Company, of close upon £1,000,000 of stock is one element of prosperity. They give us on our investment price £6. 7s. 2d. per cent. The Eastern Extension Company, in which we have again a very large holding—something like £560,000—give us £6. 16s. 5d. per cent., which you will observe is also a very good investment. These two items in our accounts give us a stamina which enables us to keep up our ordinary dividend and to slowly increase it. The Anglo-American Company, in which we hold over £1,000,000—namely £1,117,354—yields us only £3. 0s. 4d. per cent.; and the Direct Company, in which we hold £198,900, gives us a return of £6. 2s. 11d. per cent. The Anglo is the weak element in the Trust at the present moment, but I think there is a possibility of improving that investment, and probably by the time I have the pleasure of meeting you again, if I am spared for another year, I shall have the satisfaction, I think, of showing you an improvement in that respect. At all events, we never cease to think as to the best way that we can increase the value of your property and augment your dividend. All the other securities, with the exception of some minor items enable us to maintain our dividend. The Brazilian Submarine Company's shares cost us par, and pay us, on the £254,870 of stock which we hold, at the rate of £8. 10s. per cent. You will, therefore, see that we have some good things if we have some things that are not so good, and we have some things which are very good indeed, qualifying the difference in other respects. The report is full and explicit, but as regards the money received from the German Government, re-investment has been made in 1,850 shares in the Western Union Telegraph Company, and 2,050 shares in the American Cable Company. In mentioning these two investments I may say that we have always tried to give rather an international character to our investments; and as I have had the opportunity of seeing something of the American system of telegraphy—more particularly the Western Union—I am quite satisfied that their property is a most valuable one. It would probably have been better, in regard to the cables they have now in hand, if they had let this matter alone, and have kept to the land system; but they guarantee the property that we have in their submarine cable 5 per cent., and my impression is that no better guarantee or safer investment can be found. In regard to their own property, it covers an enormous area, and it is a prosperous and successful Company, and must continue to be so, because telegraphy is one of those introductions into more modern life and civilisation which must go forward. It cannot go back, for there is a demand for it; and as the world grows, so will the telegraphic interest increase. We have a small loss in exchange on the money we have invested in this particular way. The great bulk of this money came to us from the German Government. The par value of the money paid in Berlin is subject to exchange here, as you know, and that amount we have lost. The amount which it cost to bring this money home was about £1,100, but we added that to the value of the property, and it does not in any way interfere with our capital. We debited this loss to the cost of our new investments, treating it purely, on the advice of your auditors and accountants, as a capital item. There is the more reason for this course, because the securities hitherto realised by the action of the German Government have produced more than they cost, and the market value of the securities now held exceeds the aggregate cost appearing on our present balance-sheet. If we take the statement of the shares held, shown on page 6 of the accounts, and take the cost at the lowest market price, and then, again, at the highest market price, and thereafter strike an average, we shall find a mean rise in value on our stocks of £343,738. I want to draw your attention more particularly to this point. We have a large interest in the Anglo-American Company, the Eastern Company, the Eastern Extension Company, and in the Brazilian Companies; but taking all our stocks, good and bad together—taking the whole thing—we show a profit upon them at the present day of something like £343,738. There could be nothing more satisfactory than that, in my opinion; and it enables us to go on steadily. We have no reserve fund. We give you all we get, and the success of the other companies is very important to us. We are large shareholders in all these companies, and we naturally keep ourselves in touch with them, so that we are a strength to them if they are strong and good in their management, and we make them weak if we find that they are not managing as they ought to do. You will, therefore, understand that the Globe Company has considerable control over the companies now in existence; but those companies are well managed, and are successful. The Anglo-American Company gives us a low dividend, but, as I have said, it may be possible to improve the investment we have in the Anglo and the Direct Companies, and I hope when I meet you again that I shall be able to draw your attention to this subject. We should have had a full Board here to-day if Mr. Ford had been present. Mr. Ford is one of our early colleagues. He has always taken a deep interest in the undertaking, but, unfortunately for us, he has passed through that terrible scourge of influenza, and somehow or other it is clinging to him in such a way as to unfit him from being here to-day. I express my regret personally at this, and I am sure that you will all join with me, and sympathise with Mr. Ford in his absence. The Globe Company was instituted, as you know, to yield an average return by spreading the risk over a number of investments. For instance, a man holding Anglo-American stock, if he had not taken Globe stock, would now be receiving about 3 per cent. instead of 5¼ per cent., which he will now receive from the Globe Company. A great number of Anglo shareholders came into the Globe, and this has been the result to them. This is one of those things which probably you may not have sufficiently thought about—which may not have occurred to those who make their own averages. The Globe Company has made the average for them in many cases, and I think you will admit to-day that you are benefited by the Globe doing so instead of making your average for yourselves. We meet only once a year, and really it is very difficult to make up a speech which will interest you beyond giving you these simple facts. We confine ourselves, probably, more to the facts of the thing than to the sentiment which we might introduce, but this I must say, that while I would like to see a larger gathering of our constituents, yet that their absence shows the confidence which they have in us. We have a great many shareholders.

The SECRETARY: Eight thousand five hundred.

The CHAIRMAN: We have 8,500 shareholders in the Company, and I think you will admit that the confidence of that large body must be very great indeed to-day when they are represented by such a small number as we now see here. While I should like to see a larger number of shareholders present, I have the satisfaction of knowing that they trust us. When a company is prosperous, it does not require much talking from a Chairman but when a company is in difficulties a any given Chairman might have a greatdeal to do in order to make black appear white, and white appear black. We have nothing of this kind in this Company. Our task is to tell you exactly how the business is going on, and that you may feel when you retire from this meeting that the investment which you have made in this Company is in good hands, and that the chances are above the average of your receiving your dividends regularly, and probably of having them increased if slowly. I will now move the following resolution:—

"That the report and accounts for the year ended July 18, 1891, submitted to this meeting be, and they are hereby, received and adopted, and that a dividend be now declared, payable on and after this day of 3s. per share on the preference shares, less income tax, and of 4s. 6d. per share on the ordinary shares, income tax having already been deducted, making, with previous payments, a total dividend for the year of 6 per cent. on the preference shares, less income tax, and of 5¼ per cent. net on the ordinary shares."

That is the resolution which I now move.

The Marquis of TWEEDDALE: I beg to second the resolution.

The CHAIRMAN invited discussion, but no shareholder rising to address the meeting, he put the resolution in the usual way, and it was declared carried unanimously.

On the motion of the CHAIRMAN, seconded by Sir JAMES ANDERSON, the Marquis of Tweeddale was re-elected to his seat at the Board, as was also Mr. James Pender, on the motion of the CHAIRMAN, seconded by Sir HENRY D. GOOCH, Bart.

Mr. C. BURT then proposed the re-election of the auditors, Mr. John George Griffiths (of the firm of Messrs. Deloitte, Dever, Griffiths, and Co.) and Mr. Wm. Griffith, B.A.

Mr. JOSEPH KING seconded the motion, which was unanimously adopted.

Mr. W. GRIFFITH, in acknowledging his re-election, said that he could speak confidently as to the state of the book-keeping and as to the securities. Everything was in good order, and he thought they had strong grounds for hope in the future.

The CHAIRMAN having intimated that that closed the business of the meeting,

Mr. GRIFFITH proposed a vote of thanks to the Chairman and the Directors. There was, he said, no need for him to say much in support of the vote. They had themselves witnessed the urbanity and the ability of the Chairman; and it was a very strong argument in favour of the management that out of 8,500 shareholders there should be so few present. The public reputation of Sir John Pender was great, and was not confined to England, but extended over Greece, Portugal, Spain, and all the other countries which had loaded him with honours—honours not equal to those which had been conferred on their Chairman by her Majesty, but certainly honours which showed the esteem in which Sir John was held throughout the world. He was sure that few had done so much for commerce as their Chairman and those who had brought before the world the astonishing and most useful discovery of the telegraph; and they all knew what a leading part Sir John Pender had taken in the institution of telegraphy and its subsequent improvement, both in the Atlantic and the East. It was a subject of great congratulation to the shareholders to have a gentleman at their head who stood so high in the public estimation, and whose character was so calculated to improve the position which their stock held in the market.

Mr. KING seconded the resolution, which was unanimously adopted.

The CHAIRMAN: On behalf of my colleagues and myself I beg to return you thanks. It is in one way very pleasant to hear Mr. Griffith speak as he has just done, because he knows thoroughly the root and growth of this telegraph system. Only the other day he was for some hours down in the strong room examining our securities, and I think that those securities must have left a very good impression upon Mr. Griffith's mind. I think we are indebted to the real soundness of the Company's investments for the very pleasant and complimentary remarks Mr. Griffith has made. You know that he can say some very hard things. I have heard him do so, and say them in a manner which makes them felt by those to whom they are addressed. At the same time he can say some kind things, and he can do so speaking from the best authority—his own knowledge of our affairs—and we accept with the greatest pleasure the kind remarks he has made to-day. On behalf of my colleagues and myself I thank you for this renewed expression of your confidence, and you may rest satisfied that as long as these gentlemen sit on this side of the table your interests will always be their first consideration.

The proceedings then terminated.

The Telephone Company of Austria (Limited).

The eighth ordinary general meeting of this Company was held yesterday, at the offices, 53, New Broad street, E.C., Mr. Henry Grōwing, Chairman of the Company, presiding.

The SECRETARY (Mr. Richard Rodgers) read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen, the figures, which you will have seen

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in the balance sheet, showed that the profits were again ample to pay the 5 per cent. interest on our debentures, and the 6 per cent. dividend to which the holders of the preference shares are entitled. After providing for these charges the balance is left of £4,485. 18s. 9d., which, under ordinary circumstances, would go as dividend to the ordinary shares. The state of prosperity of the Company as a company is, therefore, undoubted, and I will now proceed to the paragraph which refers to this surplus, and at the same time to the Company's future. It is as follows:—"In view of the expiration, in October next, of the Company's concessions, negotiations with the Austrian Government as to the future of the Company have been in progress for a considerable time past. These negotiations are now approaching their final stage, and the result will be brought to the knowledge of the shareholders without delay, Under these circumstances your Board do not recommend at present the payment of any dividend on the ordinary shares." Since this report was issued these negotiations has advanced a step further, and a telegram appeared in one of our leading morning papers on Tuesday last, dated Vienna, Sunday night. This telegram gives the position so accurately, that we can hardly doubt that the information was supplied from official sources. The Board, therefore, feel called upon to enter into this question more fully than they would otherwise have done pending the negotiations. The facts as stated are, as I have said, correct, but the expression used that we demanded compensation to the extent of £160,000, is misleading, unless it is added that we demand this compensation in return for a very heavy capital outlay amounting to about £100,000, in constructing, equipping, and bringing to their present state of perfection the eight exchanges which we possess in the Austrian Empire, and for the goodwill of the business built up during the last 10 years. The telegram might also have added that it was under the most trying circumstances that this business was created, and that all the energy, resources, and perseverance at the command of the Board were required to produce the results attained. These results were well known both to the proprietors and to the Austrian Government, to whom we are now paying some £3,000 per annum in royalties alone, not to mention a large amount in rates and taxes, while our revenue, as the result of our large capital expenditure, shows a net profit of some £9,000, or, not deducting the royalties, £12,000 per annum. This large and prosperous undertaking the Government now wishes to take over, and, according to our reading of the purchase clause in the concessions—a reading which is shared by one of the most eminent lawyers in Vienna—the basis for fixing the purchase price is, among other stipulations, the amount of net revenue of the year preceding the purchase. The Government, however, interprets the purchase clause differently, and insists that it only applies during the continuance of the concessions, and not after the latter have come to an end, namely, on the 14th October next, the argument being that, as the Company would have to stop business on the 14th October, the revenue then ceases, and cannot consequently be taken as a basis. Such is the present legal aspect of the matter, but we have it from the present Minister of Commerce himself that the question will also be viewed by him from an equitable point of view; and we are certain that His Excellency will be the first to admit that a concession for so short a term as 10 years cannot possibly give to those who work it an opportunity of recouping themselves out of profit for any of their outlay. His Excellency will also admit that this new and extremely valuable means of communication, as introduced by us into the Austrian Empire, has met not only with the strong support of the public, but the very fact of its having met a public necessity, and, at the same time, created a new and ever increasing revenue to the State, has determined the Government to acquire it of the State. I may here say that neither money nor pains have been spared to make the service one of the best, if not the best, in Europe, and that the authorities themselves have really expressed their satisfaction to us on the subject, and commended us in an official document, as recently as January last, for the loyalty with which we have served both the public and the State. I may also add that to construct and equip afresh what we have constructed and equipped in the eight towns would cost the Government not less than the sum we are asking for, not to mention that it would take at least three to five years to get the whole of the exchanges into such perfect working as they are now. Our demand, therefore, is not unreasonable. Under these circumstances, your Board refuse to believe that the Austrian Government will deal otherwise than honourably and equitably with us, and that this opinion also prevails in influential quarters in Vienna was shown by the concluding words of the speech of Dr. Russ, when reporting on behalf of the Budget Committee on the advisability of the State purchase of the telephone nets. The following is a translation of the words:—"I am of opinion that private capital, invested in good faith, and honestly employed, should experience no damage through the acquisition by the State." We are most ably represented in Vienna by Dr. Weissel and Mr. R. Howard Krause, but in order to give every support to the negotiations they have been carrying on, three of your Directors have recently visited Vienna in order to lend their personal aid towards a satisfactory settlement. Since then the Government have made an actual offer, which, however, is unacceptable, and some of your Board have, therefore, determined to again proceed to Vienna in order to facilitate an understanding. You will gather from these observations that nothing will be omitted on our part to conduct this difficult business in the most friendly manner possible, for the Government can have no possible reason for frightening English capital and enterprise out of Austria. On the contrary, we look to the Government for the protection of English capital legitimately employed, and it is to be hoped that it will be protected from all such undeserved attacks. He concluded by moving the adoption of the report and accounts.

Mr. C. L. W. FITZGERALD seconded the motion, which was carried unanimously.

On the motion of Mr. FITZGERALD, seconded by a SHAREHOLDER, Mr. Grëwing was unanimously re-elected to his seat at the Board.

The auditors, Messrs. Deloitte, Dever, Griffiths, and Co. were also re-appointed on the motion of Mr. VANZELLER, seconded by a SHAREHOLDER.

Mr. A. H. BAKER proposed, and Mr. VANZELLER seconded, a vote of thanks to the Chairman and Directors, and the former having briefly acknowledged it, the proceedings terminated.

Telephone Company of Ireland (Limited).

The twelfth ordinary general meeting of this Company was held on Wednesday at the offices of the Company, Commercial-buildings, Dame-street, Dublin, under the presidency of Alderman Dillon.

The SECRETARY (Mr. W. F. Bottomley) having read the notice convening the meeting,

The CHAIRMAN moved the adoption of the report, which will be found below. He said the report showed satisfactory progress in the Company's business, and in telephoning generally. They had had an increase in subscription of about 15 per cent. on the year ended, notwithstanding the serious accident which disrupted traffic for a considerable time at the end of last year. It was satisfactory to say that the expenses occasioned by the accident had been defrayed without resorting to capital. They expected, however, this year they would make a considerable step in advance by the opening of the exchange between Dublin and Belfast. This they anticipated would be completed before October 1st. As arranged, the tariff from Dublin to Belfast would be fixed at 1s. for a message lasting for three minutes—that was, that a person communicating with Belfast now could send a telegram which would cost 6d. per twelve words and receive a reply costing 6d. more for twelve words—1s. in all. By the telephone he would have an opportunity of exchanging for the same price of 1s. his views with his correspondent in Belfast to the extent (if he talked fast enough) of something like 300 words. That they considered to be a very important development. The tariff from Dublin to towns inside their own district, which included the county of Louth, and therefore the towns of Dundalk and Drogheda, would be only 6d.—that was 3d. for a message each way. Of course, one could not predict what might result from the opening up of such a new system as that; but if one was to judge by the number of telegraphic messages which were exchanged between Dublin and Belfast, and between the intermediate towns, the results now would be very satisfactory to the Company for the small amount of capital which had had to be made. They had been able to arrange, as the report showed the shareholders, for working capital for this development and for the general business of the Company, on satisfactory terms. He did not know that there was anything else in the report which called for any comment. Their accounts they considered showed very satisfactory results of the working, and they hoped they would meet with the approbation of the shareholders,

Mr. ARTHUR DUDGEON seconded the motion.

Mr. HUMPHREYS asked for some information with regard to the dividend on the preference shares, which he said was half a year in arrears.

The CHAIRMAN: It is hardly fair to say they are in arrear. The dividend warrants will be issued this week.

Mr. HUMPHREYS: But with respect to the dividend that will accrue next month?

The CHAIRMAN said the account clearly showed that it would be paid, because they had an earning power of more than twice the preference dividend, but they had considered at present that while this Company was in a transition state, as, owing to circumstances known to the world in reference to patents, it undoubtedly is, they considered it better to pay the whole preference dividend at the end of the next six months. They were going to pay the dividend in arrears now, and the year's dividend at the end of the year.

The resolution was carried.

The CHAIRMAN moved that Mr. Gilbert Cockburn be elected a Director of the Company, which was seconded by Mr. DUDGEON, and carried.

Mr. JAMES EVANS moved that Mr. J. M. Kean be appointed one of the auditors, and that the joint remuneration for the auditors appointed by the Company and by the National Telephone Company be fixed at 50 guineas per annum.

Mr. HUMPHREYS seconded the motion, which was adopted, and the meeting terminated

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The following is an abstract of the report of the Directors of this Company for the year ending December 31st last:—

The number of wires, exchange and private, under rental upon December 31, 1889, was 1,309. On December 31, 1890, the number was 1,473, being an increase of 164 for the year. In the month of November last a very severe snowstorm caused a partial breakdown of the Company's system in Dublin. The exceptional damage caused by this snowstorm was due entirely to a very humid state of the atmosphere, coinciding with a temperature just over freezing point, against the consequences of which it is impossible to provide; the aqueous vapours congealing rapidly around the wires, increasing their weight, and ultimately breaking them. This unfavourable combination of extreme humidity with freezing point fortunately occurs only at very long intervals, the last occasion having been in the year 1885, when it was confined to the district lying along the south side of the Bay of Dublin, and the damage was then localised to the Kingstown and other lines in that direction. The entire cost of making good the damage has been debited to the reserve fund, which was established for the specific purpose of providing against any such contingency, and the opportunity was taken to replace nearly the whole of the old iron wires with wires of silicium-bronze, the cost thereof being also debited to

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the reserve fund. The damage was not wholly repaired during the year 1890, but the balance of the cost appears in the supplemental accounts.

In their report presented to the shareholders upon April 26, 1890, the Directors stated that additional capital was required for the extension of the business of the Company, and for the establishment of the proposed through trunk line connection between the telephone exchanges of Dublin and Belfast. It was also stated that for the purpose of providing the additional capital required, 10,000 new Five per Cent. Preference Shares were offered to the shareholders in proportion to their respective holdings; also that the subscriptions to these new shares had not been sufficient for the purposes required (1,407 shares only out of the total of 10,000 offered having been applied for), and the Directors were then authorised to issue Five per Cent. Debentures to the extent of £10,000, part of an aggregate of £25,000. These debentures were also offered to the shareholders, but up to February, 1891, 29 debentures (£2,900) only had been taken. It, therefore, became necessary for the Directors, acting under the powers conferred upon them by the resolution authorising the issue of the said debentures, to place privately a sufficient amount to meet the requirements of capital expenditure. Accordingly, the shareholders having been informed of the circumstances by circular letter, dated 25th May last, the necessary authority was given to the Directors, at an extraordinary general meeting held upon the 2nd June, to make a further issue of debentures for £12,100, bringing the total, including the £2,900 previously issued, to £15,000. These debentures for £12,100 produced, after payment of commission, &c., a net sum of £10,995. The Company, having thus been placed in possession of the requisite funds, are now, in conjunction with the National Telephone Company (Limited), proceeding as rapidly as possible with the erection of the trunk lines, not only to connect the telephone exchanges of Dublin and Belfast, but also to afford telephonic conveniences to the intermediate towns. It is expected that the lines will be open to the public on October 1st next.

One of the principal master patents expired in December, 1890, a second patent expires at the end of this month, but the National Telephone Company claim that other patents do not expire till 1893. This Company is entitled to a reduction of the instrument royalties as these respective patents expire, commencing from December last, and, in accordance with the terms of the agreement between the United Telephone Company and this Company, the amount of such reduction will be settled by arbitration. The accounts now submitted are, therefore, subject to adjustment, according to the decision of the arbitrator. So soon as the last of the patents expires, and the Company is entirely freed from payment of the royalties for the use of the instruments, it is proposed to reduce the tariff. It may reasonably be anticipated, however, that in a very short time after such reduction the revenue will be sensibly increased, and the Company's business largely developed, in consequence of the adoption of such lower tariff.

In view of the increase in the number of subscribers, and in the number of calls, and of the large increase it is expected will accrue from the connection of the telephonic exchanges of Dublin, Belfast, and intermediate towns, together with the establishment of new exchanges on the northern lines, it will be necessary to entirely re model the Dublin centre. For this purpose a convenient site has been obtained, upon favourable terms, from the Corporation of Dublin; and within the current year plans will be matured to afford the necessary accommodation. In these circumstances, it is essential that the Directors should retain in hand sufficient funds to prosecute the business to meet current demands from the public; and in view of the expiration of the patents, and having regard to the transition state in which the Company is consequently placed, it is considered that the best interests of the shareholders will be studied by expending, as far as possible, current revenue upon the necessary works to further develop the Company's business. For obvious reasons it is undesirable to attempt to place additional capital at the moment. The balance to credit of the revenue account is ample to pay not only the entire preference dividend, but would enable the ordinary shareholders to receive a considerable sum as dividend upon their shares, but it should be unnecessary to point out to the ordinary shareholders that their interests are best conserved by an increase in the gross and net revenue, and by the avoidance of the issue of additional capital upon terms other than those which are justified by the soundness of the Company's business. It is, therefore, proposed to pay only the preference dividend for the year ended December 31, 1890, and, after making the usual provision for the reserve fund, to carry forward the balance. It is anticipated that by adopting this course, with the marked improvement which may reasonably be expected in the Company's business in the next year, the Directors may be enabled to place the remainder of the preference shares at par, and thus permit of the debentures being paid off, and the capital account being placed upon a more satisfactory footing.

It will be observed that the amount standing to the credit of the net revenue account as upon December 31, 1890, including the balance brought from last account, amounts to £4,950. 10s., against £4,459. 4s. 10d. for the year 1889. Out of this sum there has been paid an interim dividend upon the preference shares for the half-year ended June 30, 1890 (£1,137. 17s. paid in July last), leaving an available balance of £3,812. 13s., as shown in the balance-sheet, which the Directors propose to allocate as follows:—For the payment of the debenture interest, £49. 4s. 3d.; for the payment of balance dividend upon the preference shares for the second half of the year, £1,153. 1s. 8d.; and to place to the credit of the reserve fund £464. 13s. 6d. (being 10 per cent. of the net profits of the year), carrying forward the balance of £2,145. 13s. 7d. to credit of the current year.

The Directors regret to record the death of their colleague, Mr. Hermann G. Erichsen. They also regret the resignation of Mr. Robert Worthington, owing to pressure of business. Mr. Gilbert Cockburn has been elected by the Board as Director, in place of the late Mr. Erichsen, and his election is submitted to the shareholders for approval. The auditor, Mr. John M. Kean, retires at this meeting, but is eligible for re-election.

Crompton and Co. (Limited).

The third annual general meeting of the members of Crompton and Co. (Limited), was held at the City Terminus Hotel, Cannon-street, on Wednesday last, Mr. R. E. B. Crompton presiding.

The SECRETARY (Mr. Francis R. Reeves) read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN said: I have now to move:—

"That the Directors' report and statement of accounts for the year ending March 31, 1891, be, and the same are, received and adopted."

With respect to the statement of accounts, I think the shareholders will agree with me that the balance of net profits, £13,030, shows a satisfactory rate of increase on the balance of the previous year, and justifies the remarks which I made at last year's meeting as to the probable steady increase of the Company's business. During the year we have executed several important contracts, and our turn over has very largely increased, but, as explained last year, these large contracts were taken at fixed rates of profits, and therefore these profits, although sure ones, are necessarily not large ones, but at the same time they constitute a very safe and satisfactory feature of the Company's business, a feature which we hope to see extended during the course of the current year. Among the important orders in hand is one for the lighting of the city of Pretoria, which is the capital of the Transvaal, and in connection with this order, Mr. J. F. Albright, my co-managing Director, has recently visited South Africa, and will himself explain to you that there is every probability of our having there laid the foundation of a large business. With regard to other contracts, negotiations are in progress for very important central stations on the Continent, any one or more of which may be decided very shortly, and will result in a large increase of business. At the same time negotiations are also on foot for central stations for several important cities and towns in England and Scotland; it is, perhaps, not advisable to mention the names of these places at the present moment, but we think we stand a very fair chance of securing a considerable percentage of them, and if these are taken on the same basis as those already referred to of a fixed percentage of profits upon the actual outlay, this will secure, as I have already said, a safe and fairly remunerative profit for the shareholders. A firm like ours, which has always occupied a very leading place among the electric lighting manufacturers of the world, has necessarily to keep abreast of all the possible modern improvements; in fact, we have ourselves to be introducers of such improvements. During the past year, I am glad to tell you, we have worked hard at the subject of electric railways, and have succeeded in carrying out for the Southend Local Board an exceedingly successful example of the modern electric railway which has received the highest enconiums from everyone connected with it, the consulting engineer (Dr. John Hopkinson, F.R.S.,) to the Local Board himself stating he never passed the final certificates of any contract with so much pleasure and leaving so little to be desired. Another cognate branch of the business which we have developed during the year, at no small expense, has been the underground haulage for mines. We have carried out two very large sets of haulage with complete success, the last and most improved one having been successfully started last Friday. The results of these, however, do not show in the accounts that are now under consideration, but come into those of the current year. We are told by those who are the largest buyers of this class of machinery, viz., the colliery owners, that the success we have obtained is such that their orders alone are likely to nearly fill our order sheets. I may mention in connection with this that a very great deal of the credit of the success of this haulage plant is due to the exertions of our South Wales agent, Mr. Howell. You will observe in the report that we have expended a very considerable sum on capital account, partly in increasing our buildings at Chelmsford and fitting them up with the proper machinery and tools, but partly in fitting up our leasehold works which we have opened in London at Lillie-road. These works have been so far of great assistance to us, and enabled us to increase our output in a manner which we should be unable to do if we had not had them. Coming back to the statement of accounts, I would refer to the question of debentures. At our last meeting I informed you that we had decided to issue our second £25,000 out of the total of £50,000 of debentures, and we then offered them to our shareholders. The response was not quite so satisfactory as we expected. At the date of the report March 31st, only £31,050 had been subscribed—viz., a little over £6,000 since the meeting last year. At the present moment there are nearly £15,000 of these debentures remaining to be placed. The Directors have not in any way pushed the issue of these debentures by advertisement or otherwise; but it is really necessary that the Company should have this further additional capital, and the Directors will be glad if any of the shareholders will send in their applications so as to close the list by subscribing for the balance. The debentures, as you are aware, are amply secured, and as the total annual interest on the issue is only £2,500, and the net profits of the Company are now over £13,000, there can be little doubt that they will receive their money regularly in the future, as they have in the past. As exemplifying the advantage to the Company of having plenty of working capital at command, I may mention that last year the Directors were, enabled by careful management and prompt payment of accounts to their creditors, to secure for the Company an additional profit by extra cash discounts of a sum in excess of the total amount required for the year's interest for the whole of the debentures then issued. With regard to the distribution of the net profits, you will see that the Directors propose, after setting aside what they consider a sufficient provision for bad debts, to declare a dividend at the rate of 3s. 6d. per share, equivalent to 7 per cent. on the preference shares, and 5s. 6d. per share, making, with the previous interim dividend, a total of 8 per cent. per annum on the ordinary shares. I may say that the good

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feeling, which I stated in my speech last year as existing between ourselves and our staff of workpeople, still continues to exist, and I have, on behalf of myself and the other Directors, to thank the staff for the satisfactory way in which they have worked during the past year, and I have to thank the works managers for the immense pains and trouble they have taken in promoting the working of the men's sick, recreation, and other clubs, and for the very cordial feeling which, in consequence exists between all the *employés* of the Company and the staff. I shall have pleasure in answering any questions of any of the shareholders present on any matters arising out of the report, and I will now conclude by moving the resolution mentioned, viz., that the report and statement of accounts be received and adopted. Resolutions will be proposed in regard to the appointment of new Directors, and I shall have pleasure later in referring to that subject. Mr. Albright, who has made a long business tour on behalf of the Company, only returned home two days ago, and he will be happy to give you some statement of his impressions and hopes of business resulting from his journey.

Mr. C. F. TUFNELL seconded the motion, which was carried unanimously.

The CHAIRMAN next moved :—

"*That a dividend at the rate of 7 per cent. per annum be declared and paid upon the preference shares of the Company.*"

Mr. J. F. ALBRIGHT seconded the resolution, which was agreed to *nem con.*

The CHAIRMAN moved, and Mr. PAYNE seconded, the next resolution as follows :—

"*That a dividend at the rate of 8% per annum be declared, and paid, upon the ordinary shares of the Company.*"

The motion having been carried unanimously,

The CHAIRMAN said that since the last meeting they had lost, he regretted to say, a very valuable Director, in the person of Sir Charles Grant. The Directors had appointed in his place, Mr. H. H. J. W. Drummond who, having been a considerable time on the Board, had been of great assistance to his colleagues. They had also secured the services of, another extremely valuable Director, Viscount Emlyn. He considered that the acquisition of these two gentlemen as members of the Board would give increased strength to the Company, and greatly increase the influence in the West of England. He had. therefore, much pleasure in moving :

"*That, in accordance with the 73rd clause of the Articles of Association the appointment of Mr. H. H. J. W. Drummond and Viscount Emlyn to be Directors of this Company is hereby approved and confirmed.*"

Mr. G. S. ALBRIGHT seconded the motion, which was carried unanimously.

The CHAIRMAN proposed, and Mr. PAYNE seconded, the following resolution :—

"*That Mr. Bernard Gibson be, and he is hereby, re-elected a Director of this Company.*"

The motion having been agreed to,

Mr. J. F. ALBRIGHT, in giving a brief description of his recent travels round the world in the interests of the Company, said that, the first place he visited was Canada, where he met the agents whom the Company had recently appointed there, and he had every reason to be satisfied with the agents they had selected. He believed that since his visit the orders that had been sent from Canada had been considerable. He visited the United States also, but, as they were aware, owing to the extremely high tariffs, it was almost impossible to do business there. After that he went to Australia, and saw the Company established there, and his impression was that they were in a position of being better represented in Australia than any other European firm or company. The prospect of business there was considerable. At the same time, it could only be done by people who knew the country well, and, in that respect, he had every reason to be satisfied. Then he went to India, where he was for a short time, and arranged for the representation of the Company by an old established house in Calcutta which had done more electrical work than any other firm. From India he went to Mauritius, where he found that all the work had been done, and no money to pay for it if there had been any to do. He then went on to Natal, proceeding at once to Pretoria, where he made final arrangements for lighting the City—a contract which was likely to be the means of establishing for them a very considerable and valuable business throughout South Africa. He had also made arrangements for their representation in other parts of the Transvaal, while he had had interviews with the Town Council of Durban and Cape Town, which might lead to profitable business. Having gone round the world he felt that he was now more competent to handle any matter in connection with their business in different parts of the globe.

Mr. G. S. ALBRIGHT proposed, and a SHAREHOLDER seconded, the next resolution, as follows :—

"*That Messrs. J. H. Duncan and Co. be, and are hereby, appointed auditors of the Company for the current year, at a remuneration of twenty-five guineas.*"

The motion having been carried,

A SHAREHOLDER proposed a vote of thanks to the Chairman and Directors.

The resolution was carried unanimously.

The CHAIRMAN briefly returned thanks, and expressed the hope that when he came before them next year it would be with a satisfactory result so far as the business of the Company was concerned.

The proceedings then terminated.

Manchester Edison-Swan Company (Limited).

The ninth ordinary general meeting of the proprietors of this Company was held on Wednesday, at the Victoria Hotel, Manchester. Mr. V. K. Armitage, Chairman, presided.

The CHAIRMAN, in moving the adoption of the report, which appears below, said that since their last meeting in February the Directors had tendered for one or two large installations, but seeing they would not get much out of the contracts, they had allowed the tenders to fall through, and just now they were not tendering for any large central lighting installation. The Directors had come to the conclusion that, at all events, some little of their money could be spent very well in another line of business. Mr. Williamson, their former Managing Director, had to go some 18 months ago to Australia for the benefit of his health. Some of the Directors of this Company formed a small company to establish Mr. Williamson in business in Sydney. Before he had been in Australia 12 months business increased so rapidly with him that the capital threatened to become but as a drop in the bucket compared with what was required. The Directors of the Edison Company who were not connected with the Williamson Company, and those who were, had had this subject thoroughly before them, and seeing that Mr. Williamson had got magnificent electric lighting orders on hand, and was likely to have others from Australian corporations, they resolved upon taking from the bank £2,500 which was lying idle, and purchasing with it shares in the Williamson Company. He (the Chairman) looked forward to the employment of a great deal of their money in Australia, but they might rely upon the Directors using extreme caution in all such investments. They would not send any money out there unless there was a chance of its being profitably employed. At the meeting of this Company, in February last, they were in hopes that the Corporation of Manchester were nearer than now seemed to be the case to a decision on their electric lighting order. They had obtained a Provisional Order, which rendered it necessary for them within a limited time to do a certain minimum amount of work. That time was running on, but they heard nothing clearly as to the carrying out of the Order, and he had begun to look less favourably than he once did upon their Company's chance of obtaining the Manchester Corporation's central lighting. In the meantime the Corporation had determined upon lighting with the electric light the Town Hall, which was outside the area of their compulsory order. The Company had tendered for the separate installation that was to be put into the Town Hall, and although a number of other firms had tendered for the same work, he believed they stood as well in as any of the others. He did not know whether the Corporation meant to run the installation themselves or to contract for it, but he sincerely believed the lighting of the Town Hall by electricity would be such an improvement upon the present illumination of the building that the Corporation would be encouraged to go on extending the electric light in future.

Mr. I. C. WATERHOUSE seconded the adoption of the report.

Mr. CHAS. AGNEW and Mr. BECHER took exception to the Company's money being invested in the Williamson Company, but the CHAIRMAN replied that the Directors had every reason to be convinced of the soundness of the investment, and the report was then passed.

Mr. F. B. ROSS was elected a Director, and the Directors' appointment of Mr. Fawcus as Managing Director was confirmed. The Directors' remuneration was fixed at £150, and Messrs. Jones, Crewdson, and Co. having been re-elected auditors, the meeting closed with a vote of thanks to the Chairman and Directors for their services.

The following is the Directors' report adopted at the above meeting : —

The Directors beg to submit the accompanying balance-sheet for the year ended May 30, 1891. The net profit, including last year's balance, amounts to £2,292. 10s., which it is proposed to appropriate as foliows : —

To payment of dividend at 5 per cent. per annum.	£1,000	0	0
To payment on account of 5 per cent. Cumulative preferential dividend on the "A" shares at the rate of 1¼ per cent. on £40,000 (the original capital of the Company), for the year ended May 30, 1883	500	0	0
Balance to be carried forward	792	10	0
	£2,292	10	0

If the above be approved, the dividend warrants will be issued on August 1, 1891.

Since the last general meeting the Directors have had to deplore the loss, by death, of their esteemed colleague, Mr. Edward Cross. The Directors have filled this vacancy on the Board by the election of Mr. Frederick B. Ross as a Director of the Company; Mr. W. P. James Fawcus, the Company's Manager, has been elected to fill the vacancy on the Board caused by the resignation, through ill-health, of Mr. J. R. Williamson, and the shareholders are asked to confirm his appointment as Director. Mr. Frederick B. Ross retires in accordance with the Company's Articles of Association : he is, however, eligible, and offers himself for re-election.

Anglo-American Telegraph Company (Limited).

The following is the report of the Directors of this Company, to be presented at the ordinary general half-yearly meeting of the proprietors, to be held at Winchester House, Old Broad-street, E.C., to-day (Friday), at 2 p.m. :—

The total receipts from the 1st January to the 30th June, 1891, including the estimated balance of £844. 7s. 3d. brought forward from the last account, are estimated at £139,184. 16s. 3d. This amount, however, is subject to rovision, as the lawsuit between this Company and the Paris and New York Telegraph Company is still pending. The traffic receipts

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show a decrease of £8,432 as compared with the orresponding period of last year, caused in a large measure by depression of trade.

The total expenses of the half-year, including the repair of cables, &c., as shown by the revenue account, amount to £54,657. 11s. 5d.

One quarterly interim dividend of 12s. per cent. on the ordinary stock, and of £1. 4s. per cent. on the preferred stock, was paid May 1, 1891, absorbing £42,000, and a second quarterly dividend at the same rates will be paid on August 1, 1891, leaving a balance of £527. 4s. 10d. to be carried forward to the next account.

The Company's repairing s.s. "Minia" has been engaged during the past half-year in the repair of the 1873 cable, off the coast of Ireland, and of one of the cables connecting Hearts Content with Placentia, Newfoundland. The vessel was chartered to the Direct United States Cable Company on March 25th for executing repairs, the remuneration for which will be found in the revenue account.

The Company's cables and land lines are in good working order, with the exception of the North Placentia Cable, which was broken on the 4th June.

New offices have been opened in Mark-lane and Tooley-street, London, and at Bradford, Dundee, Edinburgh, Leith, Newcastle-on-Tyne, Havre and Montreal. Direct communication has also been established between the Company's offices at Brest and Havre, and the Government office at the Paris Bourse, by means of a special wire conceded to the Company by the French Government.

Progress has been made, since the last report, in the lawsuit so long pending between the Anglo Company and the Paris and New York Telegraph Company. The appeal of the Anglo Company was argued before the Council of State on May 1st, and the decision of the Council of Prefecture was reversed in this Company's favour. The case will now be heard by the Court of Appeal on the question of damages, and it is expected that judgment will be pronounced soon after the termination of the Long Vacation.

United River Plate Telephone Company (Limited).

The following report is issued by the Directors of this Company, and will be presented to the shareholders at the fifth ordinary general meeting at Winchester House, E.C., on Friday, August 7th, at 12 o'clock:—

The result of the Company's operations for the year ending March 31st last shows, after paying all working expenses abroad, debenture interest, London, and other charges, a profit of £38,480. 14s. 4d., from which is to be deducted the sum of £36,049. 0s. 8d. for loss on exchange, leaving a net profit of £2,431. 13s. 8d., to be increased by the balance of £2,373. 16s. 6d. brought forward from the previous year, to £4,805. 10s. 2d. Out of this, the Directors recommend that £768. 7s. 8d. be applied in writing off one-half of the taxes suspense account, and £2,000 be written off for bad and doubtful debts in the River Plate, and that the balance of £2,037. 2s. 6d. be carried forward to the credit of profit and loss account for the current year. As shown in the balance-sheet accompanying the report, the capital expenditure during the year amounted to £3,096. 10s. 10d., as against £12,772. 8s. in the previous twelve months.

It will be observed from the profit and loss account, that notwithstanding the revolution in July, 1890, and the continued crisis in the River Plate, which has practically stopped the Company's sales' business, the gross receipts for the year are £106,259. 19s. 8d., as compared with £108,612. 2s. 7d. in the year before. The loss on exchange, £36,049. 0s. 8d., represents nearly 12½ per cent. on the Company's paid up share capital.

The working expenses in the River Plate amount to £56,941, 1s. 9d., against £63,497. 15s. 5d. during the previous year, and the London expenses to £2,732. 14s. 9d., against £3,257. 15s. 6d. Since the close of the year the London expenses have been still further reduced by about one-third.

The Directors greatly regret the loss by death of their late colleague, Mr. John Coghlan, in September last, and that Lord Thurlow, owing to pressure of other engagements, resigned the Chairmanship in April; in the place of Mr. Coghlan, the Directors elected Mr. Unwin, on his retirement from the secretaryship in March last.

Under the Articles of Association, Mr. John Irving Courtenay and Mr. John Owen Unwin retire by rotation, and, being eligible, offer themselves for re-election. The auditors, Messrs. Cooper Brothers and Co., also retire, and offer themselves for re election.

NEW COMPANIES, STATUTORY RETURNS, &c.

GEORGE W. PRIDMORE AND COMPANY (LIMITED).—This Company was registered on July 21, 1891, with a capital of £1,000 in £5 shares, by H. H. Richardson, 2, Broad-street-buildings, E.C. The objects are: To adopt and carry into effect an agreement, dated May 18, 1891, made between G. W. Pridmore, of 110, Holyhead-road, Handsworth, of the one part, and W. Everden, of Suffolk House, Cannon-street, E.C. (as trustee for the Company) of the other part, and to carry on business as manufacturers of all kinds of lamps, and of apparatus connected with the manufacture, purification, consumption, supply and distribution of gas and electricity. Office: Suffolk House, Laurence Pountney-hill, E.C.

HOME TELEPHONE COMPANY (LIMITED).—This Company was registered on July 27, 1891, with a capital of £500, in £5 shares, by H. P. Spottiswoode, 32, Craven-street, Charing-cross. The objects are: To acquire any Letters Patent, rights, or privileges for the use, sale, or manufacture of any telephone, telegraph, electric light, electric power apparatus, or any other invention, instrument, or apparatus connected with the utilisation of electricity; to contract for the carrying on of any telegraphic, telephonic, electric light or power, or any other business; and to establish and conduct any system of telephonic or telegraphic communications, or for the transmission, storage, utilisation, or application of electricity. The regulations of Table A (First Schedule, Companies Act, 1862) mainly apply. Office: 85, Queen Victoria street, E.C.

MORECAMBE ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—This Company was registered on July 27, 1891, with a capital of £15,000, divided into 14,950 ordinary and 50 founders' shares of £1 each, by J. Tilly, solicitor, Lancaster. The objects are: To acquire the rights of T. R. Andrews and T. Preece (who are the undertakers of the Morecambe Electric Light and Power Order, 1890) of and in the undertaking authorised by that Order. To become the undertakers of that Order, by adopting and carrying into effect an agreement, dated June 27, 1891, made between the above T. R. Andrews and T. Preece of the one part, and J. Jowett (for and on behalf of the Company) of the other part, and to carry on the business of electricians, mechanical and electrical engineers, manufacturers of and workers and dealers in electricity, electric motive power, and electric light for all public and private purposes. Registered without Articles of Association. Office: 18, The Crescent, Morecambe.

SOUTH BEACH LAND AND BUILDING CORPORATION (LIMITED).—This Company was registered on July 25th, with a capital of £5,000, in £5 shares, by Jordan and Sons, 120, Chancery-lane, W.C. The objects are: To acquire and develop, build on, or otherwise turn to account land at Pwllheli, in the county of Carnarvon, to construct, maintain, improve, work, and control waterworks, gasworks, roads, tramways, electric power, heat, and light, supply works, telephone works, and other conveniences of public utility, and to carry on the businesses of builders, decorators, merchants, electrical engineers, &c. Registered without Articles of Asociation. Office: Gwyddonfa, Pwllheli, North Wales.

TAYLER SMITH ELECTRIC COMPANY (LIMITED).—This Company was registered on the 21st inst., with a capital of £6,000, divided into 300 Six per Cent. Preference and 300 ordinary shares of £10 each, by Cave and Co., solicitors to the Company, 4, Fenchurch-street, E.C. The objects are: To purchase or otherwise acquire the business and goodwill of Mr. Thomas Tayler Smith, electrical engineer, of 4, Circus-place, London, E.C., and to carry on the business of electrical engineers, contractors for electric lighting, and other works connected with the use of electricity, and manufacturers of and dealers in electric plant, fittings, and apparatus. The first subscriber is the Earl of Shrewsbury and Talbot, Ingestre, Stafford, who takes one preference share. The business of the Company is to be carried on by managers, the first being T. T. Smith, of the above address, and Keppel Stephenson, of 34, Beaufort-gardens, S.W. Office: 53, South Molton-street, Oxford-street, W.

AUTOMATIC ELECTRIC RAILWAY SIGNAL COMPANY (LIMITED).—A meeting of this Company was held on July 22, 1891, for the purpose of having an account laid before them, showing the manner in which the winding up of the Company had been conducted and the property disposed of, and the same was done accordingly. Offices: 11, Rumford place, Liverpool.

BLOCKLEY ELECTRIC LIGHTING AND MANUFACTURING COMPANY (LIMITED).—The third annual return, made up to June 13th, was filed on June 20, 1891. The Company, which was registered on December 16, 1887, has a capital of £20,000, in £5 shares. 508 shares have been taken up, the full amount called upon each, and calls paid amounting to £2,540. Office: Blockley, Worcester.

CITY OF LONDON ELECTRIC LIGHTING (PIONEER) COMPANY (LIMITED).—The statutory return of this Company, made up to June 8, 1891, was filed on the 20th June. The Company, which was registered on the 5th February last, has a nominal capital of £100,000, in £50 shares; 1,000 shares have been taken up, upon each of which £25 has been called and paid. Offices: 1 and 2, Great Winchester-street, London, E.C.

ELECTRIC AND GENERAL INVESTMENT COMPANY (LIMITED).—The first annual return of this Company, made up to July 1st, was filed on July 11, 1891. The Company, which was registered on May 20, 1890, has a capital of £200,000, divided into 39,900 ordinary and 100 founders' shares, of £5 each; 20,000 ordinary, and all the founders' shares have been taken up, and upon the ordinary shares £1 per share has been called and paid, while upon the founders' shares the full amount has been called and paid, the calls paid amounting to £20,500. Office: 1 and 2, Great Winchester-street, E.C.

HOUSE-TO-HOUSE ELECTRIC LIGHT SUPPLY COMPANY (LIMITED).—The annual return of this Company made up to July 3rd last, was filed on the 11th. The Company, which was registered on February 20, 1888, has a nominal capital of £350,000, divided into 100 founders', 57,900 ordinary, and 12,000 preference shares, each of £5 each. 100 founders', 8,322 ordinary, and 342 preference shares are taken up, upon each of which the full amount has been called. The calls paid amount to £38,278, considered as paid on 100 founders' and 1,000 ordinary shares, £5,500 and unpaid to £42. Office: 117, Bishopsgate-street Within, E.C.

SHROPSHIRE ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The statutory return of this Company, made up to June 12, 1891, was filed on June 19th last. The Company, which was registered on January 30th last, has a nominal capital of £25,000, in £10 shares. 275 shares have been taken up, but upon these no calls have been made. The total allotment money paid amounts to £510, and unpaid to £40. Registered office, 9, The Square, Shrewsbury.

STAMFORD HILL, TOTTENHAM, AND EDMONTON ELECTRIC LIGHT AND POWER SUPPLY (LIMITED).—The following special resolution was

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passed on June 3, 1891, and confirmed June 24, 1891:—"That the name of the Company be changed to the Putney and Hammersmith Electric Light and Power Supply (Limited)." The approval of the Board of Trade to the above change was granted on July 1st, and filed on July 6, 1891.

CITY NOTES, &c.

AKESTER ELECTRIC MOTOR COMPANY (LIMITED).—A meeting of the shareholders in this Company was held at the Cannon-street Hotel, on Wednesday last, but the proceedings were private.

CITY AND SOUTH LONDON RAILWAY COMPANY.—The traffic receipts of this Company for the past week amounted to £686.

HEROLD TELEGRAPH COMPANY OF BERLIN.—At a general meeting of this Company it has been decided to increase the capital from 800,000 marks to 1,000,000 marks.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The Directors recommend a half-yearly dividend at the rate of 8 per cent. per annum.

NORTH METROPOLITAN TRAMWAYS COMPANY (LIMITED).—The Directors, in their report just issued, allude to their unsuccessful application to Parliament to amend Section 4 of the North Metropolitan Act, 1890, which gives power to the Local Authorities to give their consent for the use of electricity on the Company's lines on such terms and conditions as they might think fit. The arrangements entered into with the General Electric Power and Traction Company (Limited), however, for working the traffic on the Barking-road section are still in operation, and during the last half-year 37,767 miles have been run by electricity.

SANITAS COMPANY (LIMITED).—The Directors have declared an interim dividend at the rate of 10 per cent. per annum for the six months ended June 30th last, free of income-tax, and payable on or after September 1st next. The transfer books will be closed from August 25th to August 31st next.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The Stock Exchange Committee have ordered 5,324 additional shares, Nos. 92,048 to 97,371, of this Company to be quoted in the official list.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, July 22.	Price Wednesday, July 29.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending July 29. Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
£1,300,980	Stock	12/0	Anglo-American	44⅛ 45½	44 45	6 7 9	Jan., Apr., July, Oct.	44⅞	44
£2,849,510	Stock	21/0	Do. Preferred	83½ 84½	83½ 84½	6 14 11	" "	84⅜	83⅜
£2,849,510	Stock	..	Do. Deferred	9¾ 10¼	9½ 10	..	.. "	10	9¾
£250,000	100	4%	African Direct, Telegraph 4% Debentures	98 101	98 101	3 19 3	January and July ..	100½	..
130,000	£10	5/0	Brazilian Submarine	11½ 12	11⅜ 12⅛	6 18 9	Mar., June, Oct., Dec.	12⅛	11⅞
£69,200	£100	5%	Do. 5 per Cent. Bonds	101 104	101 104	4 16 2	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107	103 107	4 13 6	June and December	106	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	103 107	105 109	6 3 10	April and October ..	..	..
16,000	10	8/0	Cuba Submarine	10½ 11½	10½ 11½	6 19 2	February and August	..	..
6,000	10	10%	Do. Preference 10%	17 18	17 18	5 11 1	" "	..	..
12,931	5	3 2/3	Direct Spanish (£4 paid)	3½ 4	3½ 4	7 0 0	April and October..	3½	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	10½ 10¾	10½ 10¾	6 10 3	Jan., Apr., July, Oct.	10⅝	10⅜
400,000	10	2/6	Eastern	14⅞ 15⅛	14⅝ 15⅛	4 5 11	" "	15 1/16	14 13/16
70,000	10	6%	Do. 6 per Cent. Preference	15 15½	15 15½	3 17 5	" "	15½	15⅜
£1,200,000	Stock	6%	Do. 4 per Cent. Mort. Debenture Stock	106 109	106 109	3 13 5	May and November	108½	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	107 110	4 10 11	February & August	..	..
250,000	10	2/6	Eastern Extension	14⅞ 15⅛	14⅝ 15⅛	4 12 7	Jan., Apr., July, Oct.	15⅛	14 13/16
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock	105 108	105 108	3 14 1	February & August	..	..
£85,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	101 104	101 104	4 16 2	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	101 104	101 104	4 14 4	..	..	..
180,227	10	2/6	Globe Telegraph and Trust	9⅝ 9¾	9¾ 10	5 10 0	Jan., Apr., July, Oct.	10	9¾
180,042	10	6%	Do. 6 per Cent. Preference	15 15½	15 15¾	3 18 8	" "	15½	15
150,000	10	5/0	Great Northern	18¼ 18⅝	18½ 18⅝	4 10 8	Jan., April, and July	..	..
£221,000	100	5%	Do. 5 per Cent. Debentures, 1883	105 108	105 108	4 12 7	March & September	..	..
17,000	25	37/6	Indo-European	39 41	39 41	4 11 3	May and November	..	..
38,348	10	5/0	London latino-Brazilian	6½ 7⅛	6½ 7⅛	6 0 0	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106 109	106 109	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's	8 8½	8 8½	4 14 1	April and October..	..	..
3,381	£100 Cert.	£1	Submarine Cables Trust 6%	115 120	115 120	5 0 0	" "	..	..
15,609	10	6/0	West African Telegraph	8 9	8 9	5 11 1	January and July ..	..	..
£281,400	100	5%	Do. 5 per Cent. Debentures	96 99	96 99	5 1 0	March & September	..	..
30,000	10	2/0	West Coast of America	3 4	3 4	..	January and July ..	..	..
£150,000	100	8%	Do. Debentures 8% 1902	97 102	97 102	7 16 10	June and December	..	..
88,321	10	9d.	West India and Panama	2 2¼	1⅞ 2⅛	..	..	2 1/16	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10 10½	10 10½	5 14 3	May and November	10¼	10⅛
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9 10	9 10	6 0 0	" "	..	..
61,683	15	9/0	Western and Brazilian	11 11½	10¾ 11¼	6 13 4	" "	11 3/16	10 15/16
30,364	7½	1/6	Do 5 per Cent. Cumulative Preferred	6½ 7	6½ 7	5 7 3	—	6⅞	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	4¼ 4¾	4¼ 4¾	..	..	..	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	104 107	104 107	5 12 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103 106	103 106	5 13 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	117 122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	101 105	101 105	5 14 3	March & September	..	..
			TELEPHONES.						
224,850	14/0	0/4½	Consolidated Telephone Const. & Maintenance	1/16 3/16	1/16 3/16	7 9 4	May and November	1/16	..
220,000	£1	4·76	Oriental (11s. paid)	1/16 1/16	1/16 1/16	6 3 11	Yearly	..	..
438,984	5	3/6	National	4⅛ 4⅜	4⅜ 5	6 0 0	June and December	4 1/16	4 1/16
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½ 13⅛	12⅝ 13⅛	4 8 11	" "	13⅛	..
15,000	10	6%	Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd)	12½ 13	12⅝ 13	3 14 1	" "	..	..
350,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd)	105 107	105 107	4 4 1	..	106½	105½
58,000	5	1/0	United River Plate	2 3	2 3	..	January and July ..	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85 95	85 95	5 5 8	..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
1,000	£50	..	City of London Electric Lighting (£50 fully paid)	60 62	60 62	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	4½ 5	4½ 5	..	..	..	..
5,322	£5	..	House to House Electric	4⅜ 5⅛	4⅜ 5⅛	..	..	..	..
30,000	£5	..	Liverpool Electric Supply (£3 paid)	2⅜ 2⅝	2⅜ 2⅝	3 13 1	..	..	..
111,000	5	..	London Electric Supply	1⅝ 2	1⅝ 2	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	9⅜ 10⅛	9⅜ 10⅛	4 7 7	..	10⅛	..
7,730	£5	..	St. James' and Pall Mall	6⅝ 7⅛	6⅝ 6⅞	..	..	..	..
..	..	7%	Do. 7% Preference	3¼ 3⅜	3⅜ 3⅝	..	..	..	..
42,853	5	..	Westminster Electric Supply (£5 paid)	4⅜ 5⅛	4⅜ 5⅛	..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	..	Brush Electrical Engineering	2⅜ 2⅝	2⅜ 2⅝	..	..	2⅜	..
69,996	2	6%	Do. 6 per Cent. Preference	1⅞ 2	1⅞ 2	6 0 0	June and December	2	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	4 5	4 5	7 0 0	January and July ..	..	..
17,139	5	..	Edison and Swan United	.. ..	.. ..	..	—	..	..
45,000	10	6%	Electric Construction	2½ 3½	3 4	..	—	..	..
70,000	2	10/0	Elmore's Patent Copper Depositing	3¼ 3⅜	3⅛ 3⅜	..	—	3⅜	3 1/16
20,000	5	..	Fowler-Waring Cables (£4 paid)	2 3	2 3	..	..	..	..
41,669	10	10/0	India Rubber, Gutta Percha & Telegraph Works	18½ 19½	18½ 19½	5 2 7	February & August	19½	19½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103 105	103 105	4 5 9	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	7½ 8½	7½ 8½	11 15 3	..	..	..
11,334	£10	5/0	Do. Preference	9¼ 9⅝	9¼ 9⅝	8 4 1	..	..	..
75,941	5	2/1½	Swan United (£3. 10s. paid)	4½ 5	4⅝ 5	6 19 10	May and November	4⅝	4 1/16
37,356	12	12/0	Telegraph Construction and Maintenance	44 46	44 46	5 4 9	March and July.....	45	44½
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101 104	101 104	4 16 2	January and July ..	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£3 paid)	2⅛ 2⅜	2⅛ 2⅜	..	..	..	..
—	£5	..	Do. Preference (fully paid)	3⅞ 4⅛	3⅞ 4⅛	..	..	..	..
			RAILWAYS.						
50,000	£10	..	City and South London Railway	4 5	4 5	..	..	..	..

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THE ELECTRICIAN:

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NOTES.

At a special general meeting of the Institution of Electrical Engineers, which is not likely to be largely attended at so late a time of year as August 13th, the alteration of those Articles of Association which refer to the subscriptions and entrance fees will be discussed. As will be readily guessed, the alterations refer to an increase of the subscriptions; but they will only affect new members who are elected after the end of the present year. By members we include associates and students, but the Institution draws a peculiar distinction between its members proper and the other classes. Members only are invited to this meeting, although associates and students will be quite as much affected by the resolution which will be placed before it. The Institution of Civil Engineers includes as members both its associate members, its associates, and its students; but the two former classes are corporate members. The large body of associate members are entitled to all the privileges, and are not excluded from such meetings as the above, nor are they debarred from voting, or from acting as scrutineers for the ballots. The Civil Engineers hold out no inducements to the associate members to become full members by allowing the latter to control the affairs of the Institution, but make such full membership an honorary distinction.

A still more peculiar custom of the Institution of Electrical Engineers is to demand an additional entrance fee for transfer from one class to another. We do not complain so much about the fee, which is only, perhaps, a little annoying because it is so unusual, for we are fully alive to the fact that one of the chief difficulties with which the Institution has to contend is its small revenue; but why call these entrance fees? If a student does not actually enter the Institution on his election, as he does when he joins the Civil Engineers, he at least should be considered to do so when he becomes an associate. If more fees are wanted, let them be called transfer fees, for that is what they really are. We hope that there will be a rush of new members at the beginning of the next session, who will be anxious to get in before the fees are raised, and thus benefit the Institution by a material increase of numbers as well as an addition to its revenue. As it is possible that the resolution may be amended at the meeting next Thursday, we have not printed it in this issue, but hope to give it as it finally passes the meeting.

On Friday last the Barnet Local Board sealed a contract with the District Gas and Water Company for the public lighting, and so terminated the unfortunate and ill-advised attempt to light streets with glow lamps. The contractors have a distinct grievance against the Board, since the electric lighting was carried out on the understanding that assent would be given to their application for a Provisional Order. But there have been so many failures, and so many of the lamps have been below the proper candle-power, that much dissatisfaction has been caused, and, no doubt, some reasons could be put forward for the refusal to support the contractors' application for an Order. The special pleading which is sometimes used with no little ingenuity to show that lighting by glow lamps is, as a rule, as cheap as gas, cannot be applied to such a concern as the Barnet lighting. The arguments about health, cleanliness, and coolness do not apply, and we do not see how the glow lamp can compete with gas for street lighting, except under favourable conditions, and on a much more important scale than Barnet. It is far too good for such a purpose. The contractors seem to have made a final effort to run an arc lamp, but its behaviour was not satisfactory, and, on account of the breach of faith of the Board and other conditions imposed, they have not attempted to renew the contract. Contractors do not require such a warning as this to teach them that street lighting is the least profitable work that they can touch, and that glow lamps, even if properly put up, offer but little advantage for this purpose over gas, except the saving of a lamplighter.

The case of Crompton and Company *v.* Phillips raised, as Lord Justice Lindley observed in the Court of Appeal, an important question, not only to the parties but to all persons interested in electric lighting. A considerable quantity of wire was bought by the plaintiffs for out-door work in Chelmsford. It does not appear that any specification was given or guarantee asked for the actual insulation resistance, and it will be remembered that the Board of Trade rules for aerial conductors (*The Electrician*, August 29, 1890) do not require so many megohms per mile, but (§ 33) that "every high-pressure aerial conductor shall be continuously insulated with a durable and efficient material, to be approved by the Board of Trade, to a thickness of not less than one-tenth part of an inch, &c." The wire in question was described as C quality, which, as it stands, only implies that it ranks between B and D, and, therefore, while not as good as it might be, is better than some other quality which is still covered with vulcanised rubber. Whatever else quality C meant, said Lord Justice

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KAY, it meant at least this—that the wire was insulated. The details of the experts' evidence were given in full in our issue of June 26th, and there it appeared that there were numerous cracks and open seams in the insulation, but in the opinion of two engineers C quality wire was suitable for house work for 100 volts. Fortunately, the jury were not asked to decide upon the kind of insulation suitable for out-door or for house work, and it is hardly likely that they would be led away to imagine that a wire which was not good enough to put up on poles was really intended, and was a proper article, to put into a house.

IT appears to us that, so long as it passes the Board of Trade, an overhead wire may have cracks at every five inches instead of every five yards, and be little the worse for them provided proper insulators are used; but we are sorry to learn that anything but a really first-rate quality of insulation should be thought "good enough" for house work. For overhead work, a fair insulation and a strong mechanical protection are needed, and the Board of Trade regulations say nothing about insulation except that which may be provided by good insulators on the posts. For indoor work, there is ample mechanical protection in the wood casing, and what is wanted is a first-class insulation which shall resist damp.

UNDER the not very appropriate title of London Day by Day, the *Daily Telegraph* inquired yesterday why electric traction is a success in America but a comparative failure in England; and puts forward the statement that experts say it is due to the conditions imposed by Parliament that electrical engineering generally has advanced in this country at such a snail's pace. We do not know who these experts may be, and cannot recall any conditions, other than the Board of Trade regulations for aerial conductors, which can be said to hamper electric traction. The reason simply appears to lie in the fact that nearly all the traction in America is done with a trolley wire, and this would not be tolerated in our streets. It is precisely the same with electric lighting. We have heard for years past, that Americans have been ahead of us in electric lighting; but it was of a quality, to put it mildly, unsuitable for this country. Electric lighting is progressing fast enough now, as fast as anyone could wish, and it is all the better for having been slow. We are confident that electric traction will come on just as surely, and with as many advantages due to maturity. The only obstacle of this kind encountered by electric traction have been the conditions imposed by Local Authorities. The Lineff closed conduit system, which was at one time very promising, appears to have suffered severely from this form of opposition.

THE sections on the influence joints in Prof. EWING'S articles on magnetism, which will be found in another column, treat of a matter which is of considerable interest to dynamo makers. The question was first raised in a Paper by Prof. EWING and Mr. LOW, at the British Association, at Manchester, in 1887 (*The Electrician*, Vol. XIX., p. 439). It was argued, during the discussion which followed that Paper, that little or no advantage could be obtained by screwing the limbs of magnets more tightly to the yoke, for the pressures required to diminish the magnetic resistance of the joint to any useful extent were far greater than could be attained in practice. Prof. EWING'S researches show very clearly the exact effect which may be expected, and the equivalent air-gap is easily calculated, and is more accurate than the addition of eight inches to the length of the bar, which was suggested in the discussion to which we have referred. It seems probable that the curvature of the line in Fig. 134, page 380, of the present issue is simply due to errors of observation, and this makes the correction a very simple one. The continuation of these articles deals with rough joints, and the effect of successive joints. A rough joint offers only slightly more resistance than a well surfaced joint, but the resistance of the former is reduced comparatively little by pressure. Engineers will, therefore, merely waste money in scraping up their joints, and may easily calculate to what extent it is worth while to avoid them by using expensive forgings.

WE present to our readers this week three articles on the poly-phase alternate current system. We have held over the abstract of VON DOLIVO-DOBROWOLSKY'S Paper for some weeks until we could give an account of a practical form of dynamo used, and this will be found in the description of the 300 H.P. Oerlikon dynamo devised by Mr. C. E. L. BROWN. In another column will be found a very useful *resumé* of the subject in the form of a translation of a Paper by M. HOSPITALIER.

Telephone Trunk Wires.—A third telephone wire is to be established between Brussels and Amiens.

The New North Sea Cable.—The laying of the new cable between Denmark and France, that is from Fanö to Calais, was successfully completed last week.

Prague.—The electric railway to the Baumgarten was opened on July 18th. The hours of running are from 6 a.m. to 9 p.m. in the summer, and from 7 a.m. to 8 p.m. in the winter.

Lynton.—The Local Board has received notice of intended application for a Provisional Order from the Devon Electric Lighting Company.

A Good Rule for Street Lighting.—According to a gas contemporary, the only rule for street lighting that operates with local authorities is to pay for gas as little as they can, and for electricity as much as they dare.

Telephonic Transmission.—On Sunday last the whole of the service at Christ Church, Birmingham, was transmitted to Kidderminster to the house of Mr. Johnston, the local manager of the National Telephone Company.

West Ham.—At the last meeting of the Town Council it was decided to employ Professor H. Robinson to inspect the district, and to advise as to the best method and approximate cost of the installation of an electric system.

Owens College, Manchester.—The Session of this College begins on the 6th October. A Special Course has been arranged on the Technical Applications of Electricity. For further particulars, see our advertisement columns.

Oxford.—Some time ago a Provisional Order was granted to the Electric Installation and Maintenance Company. Plans have now been presented to the General Purposes Committee of the Corporation. The low tension system, with sub-stations, will be employed.

Frankfort Exhibition.—Numerous favourable replies have been received in answer to the recent circular of the Electrical Trades Section suggesting that a visit should be paid to the Frankfort Exhibition in a party. There is, therefore, little doubt that the visit will take place.

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The Telegraph Business at the House of Commons.—The postal business transacted at the House of Commons this Session has been exceptionally heavy, especially in the telegraph department. The number of messages despatched was 51,637; and no fewer than 17,258 were received.

"Electricity."—The latest addition to the formidable host of American electrical publications is a weekly illustrated journal entitled *Electricity*, published at Chicago. *Electricity* is to be "popular and practical as well as merely technical and theoretical," and in the first number there is certainly a judicious blending of everything electrical.

Copper.—The July statistics of the copper trade, which have been issued by Messrs. Henry R. Merton and Co., show that although the new supplies have been decidedly below the recent average the deliveries have been still smaller. They have, indeed, been absolutely less than in any month since March, 1889, and the visible stocks which have, up to the present, shown a steady diminution, have risen 1,400 tons during July.

The Post Office and the Telephones.—The Wolverhampton Chamber of Commerce lately received a communication from the Postmaster-General, stating that the Government did not contemplate immediately taking over the undertakings of the telephone companies; but were prepared to establish telephone exchanges in centres where required, and that the whole question of telephonic communication was still under consideration by the Department.

The Grassot Electrolytic Meter.—The electrolytic electricity meter devised by M. E. Grassot, has certainly the merit of originality. It consists of a silver wire 5mm. in diameter, placed in a glass tube, and dipping for a distance of about 3mm. into a solution of nitrate of silver. The silver wire is an anode to a cathode of zinc, and as it loses weight it is made to descend and pull round a drum actuating a train of clockwheels and indicating dials.

Gas and Electricity in France.—From recent accounts it appears that the consumption of gas in Paris in 1890 exceeded that in 1880 by 26·2 per cent. While the number of consumers increased 56·8 per cent., the amount per consumer diminished 19·5 per cent. The same account states that in *three* years the number of arc and glow-lamps has increased 140 and 170 per cent. respectively. The consumption of petroleum in France has increased 47 per cent. in those ten years, while that of gas, in the whole of France, has grown 62 per cent.

City and South London Electric Railway.—In view of the extension of the line from Stockwell to Clapham, for which the Company already have Parliamentary powers, they are making arrangements for a considerable extension of the generating plant at the Stockwell Station. They have placed the order with Messrs. Mather and Platt, of Manchester, for a fourth generating dynamo, similar to the three at present working the line. The dynamo is to be of the "Edison-Hopkinson" type, and to have an output of about 400 H.P. The Company have also ordered a fourth engine from Messrs. John Fowler and Company, similar to the three existing engines, and have made arrangements for an increase of their rolling stock.

The Société d'Encouragement.—The Société d'Encouragement has offered a prize, for 1893, of 3,000fr., which will be awarded to anyone discovering a substance partially, if not wholly, taking the place of gutta-percha, or to anyone who has made the most deserving contribution to the knowledge of the planting, acclimatisation, or improvements in the culture of the gutta tree. Another prize of 2,000fr. is for the best apparatus or industrial method by means of which the insulation of the different parts of an electrical plant can be measured while the full current is on. Further particulars can be obtained from the secretary of the Society, 44, Rue de Rennes, Paris, before December 1, 1892. Communications should, if possible, be in French.

The International Electric Company of Vienna.—The following particulars are given concerning this Company's central station in Vienna, which has now been running since November last. The Ganz system is employed. At the central station are six Steinmüller tubular boilers working at 150lb. pressure, and four compound engines, three of 600 H.P., and the fourth of 300. The former is coupled direct to 400 unit Zipernowsky alternators, making 125 revolutions, and the latter to a 200-unit machine, running at 170 revolutions. The excitation is effected by three 35-unit machines coupled direct to a Westinghouse engine. Three Berthoud-Borel cables capable of supplying 23,000 16 c.p. lamps start from the distributing board. The total length of conduits laid is over 20 miles. Transformers for 2, 4, and 8 units are employed, and Blathy meters are in use.

The French West Indian Cables.—Mr. W. Sharpey Seaton informs us that, on the 31st ultimo, his engineer-in-chief, Mr. Theophilus Smith, telegraphed him that the Cayenne-Viseo cable was successfully laid. This completes the system of about 2,500 nautical miles which has been laid for the Société Française des Télégraphes Sous-Marins. The first expedition was directed by Mr. Seaton in person, the second was entrusted by him to Mr. Theophilus Smith, who has been assisted by Messrs. Stallibrass, Page, Schischkar, Hall, Roussel, Fisher, Bevan, Sullivan, Spain, and other engineers and electricians, as well as by Captain Stonehouse and Mr. Dunn, the chief of the engine room. The first official message despatched was that of the Governor of Cayenne to the President of the French Republic, conveying the best wishes of the Colony for M. Carnot.

Frequency of Thunderstorms.—A German periodical gives statistics concerning the frequency of thunderstorms in various regions of the world. Java has thunderstorms on the average 97 days in the year; Sumatra, 86; Hindostan, 56; Borneo, 54; the Gold Coast, 52; Rio de Janeiro, 51; Italy, 38; West Indies, 36; South Guinea, 32; Buenos Ayres, Canada, and Austria, 23; Baden, Wurtemburg, and Hungary, 22; Silesia, Bavaria, and Belgium, 21; Holland, 18; Saxony and Brandenburg, 17; France, Austria, and South Russia, 16; Spain and Portugal, 15; Sweden and Finland, 8; England and the high Swiss mountains, 7; Norway, 4; Cairo, 3. In East Turkestan, as well as in the extreme north, there are almost no thunderstorms. The northern limits of the thunderstorms are Cape Ogle, northern part of North America, Iceland, Novaja, Semelja, and the coast of the Siberian ice sea.

The Electric Lighting Business in Paris.—Judging by the following remarks of the *Bulletin International de l'Electricité*, the electric supply business, in spite of the high price of gas, is not giving entire satisfaction to those engaged in it. "There are rumours going about with regard to the uniting under one management of several of the Paris electric lighting concessions. The individuals who are so well acquainted with the projects of the Rothschilds ought to know that they have enough to do in working the district they possess, without taking over ancient concessions of doubtful value, or promoting new concessions. There are, indeed, some who do not think the business sufficiently spoilt, and who talk of supplying the hecto-watt hour taken at the station door for 2·5 centimes. We fail to see what would be gained by a combination of the kind, either from the financiers' or the contractors' point of view. Both are wealthy, but not wealthy enough to stand the consequences of such an absurd enterprise."

Some Researches in Magnetism.—In a recent number of *Wiedemann's Annalen* Karl Frome states that some earlier experiments led him to the conclusion that the maximum value of the permanent (residual) magnetic moment P.M. attained by a body previously unmagnetised through the repeated application of the same magnetising force P, could neither be raised nor changed by the application of a force equal to or smaller than P, and acting in the same direction. Later tests, however, had convinced him that this was incorrect. The magnetised bodies consisted of bundles of iron wire, pieces of wrought iron, and mild steel. One experiment was as follows:—A piece of iron was magnetised to a constant value of P.M. by means of repeated applications of a current of one ampere and then subjected to the influence of a smaller current. In all cases the application of the weaker force due to the smaller current effected at first an increase in P.M. until it reached a maximum, and then a decrease through the original value to a negative maximum, and finally an increase again. The communication further deals with the influence the shape of an

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iron core has upon the effect of small forces. Such an influence appears to exist, though its nature is not very clear.

The Taunton Exhibition.—The West of England and South Wales Electrical Exhibition opened, on Saturday last, at Taunton. It is held in the Central Station of the Taunton Electric Light Company; the yard and all available space having been covered in for the purpose. The opening ceremony took place at 3:30 p.m., when Field-Marshal Sir Lintorn Simmons, in a short speech, declared the Exhibition open. The Exhibition is not in a finished state at present. Several cases of goods have yet to be unpacked, and the stalls are not for the most part properly arranged. There are about 40 exhibitors, amongst whom are Messrs. Rashleigh Phipps and Dawson, Messrs. King, Mendham and Co., Messrs. Davis and Sons (Bath), the Blackman Ventilating Company, MM. Richard Frères, Mr. F. M. Newton (Taunton), the Keys' Electric Company, the Bath and Exeter Electric Light Companies, Messrs. Appleton, Burbey, and Williamson, the Babcock and Wilcox Company, and Messrs. Laurence, Scott and Co. One of the best and most interesting exhibits is that of Mr. F. M. Newton, who shows a "Taunton" dynamo driven by a 5 H.P. Priestman oil engine, charging a set of 34 accumulators; patent switch board hinged to a fixed ornamental post, so that wires, &c., may be examined at back, patent brush holders, &c. There is a small electric launch moored near the bridge, which will make short trips on the river. The electric "bus" has not yet commenced to run. The attendance is fairly good.

Thunderstorms.—During the past few days severe rainstorms, accompanied by thunder and lightning, have occurred all over Europe and the United Kingdom. At the beginning of the week in the course of 24 hours some half-dozen thunderstorms, of more than usual severity, occurred along the Norfolk and Suffolk coast. At Lowestoft a flash struck a house near the hospital. It cut the chimney in two, and, entering the lower room, destroyed the chimney-piece, split the fire-grate, and carried a portion of it into the centre of the room. At Gorleston the National Lifeboat house was damaged by lightning. The roof was stripped of the slates, and the glass in the windows was shattered. At Croydon a labourer and his wife were struck by lightning. The former was killed on the spot, and the woman has since died from shock to the system. On Tuesday many parts of the country were again visited by thunderstorms. Several houses were damaged and a large number of cattle killed. In Germany, during a thunderstorm on Friday last, a detachment of the First Regiment of Guards, while engaged in musketry practice at Potsdam, was struck by lightning, and four of the men were deprived of consciousness. On Monday the town of Rathenow was visited by a thunderstorm, during which the large garrison stores were struck by lightning and set on fire. The flames spread very quickly, and the entire magazine was soon reduced to ruin. On the lowest estimate there is a loss of 1,500,000 marks.

The Wurts-Winsor Lightning Guard.—The Wurts-Winsor lightning guard, says the *Electrical World* of New York, has a cylindrical air chamber of brass, each end of which is covered with a marble plate. Two discharge points on opposite sides of the air chamber, consisting of brass tubes tipped with carbon, are attached to lever arms, so as to swing freely through openings in the marble plates. Within the air chamber is a fixed carbon ball, and the two discharge points approach this ball to within one-sixteenth of an inch. The ball is earthed and the lever arms connected to the respective poles of the generator. If a lightning discharge comes in from the line a discharge takes place from the two discharge points to the carbon ball, and from thence to earth. The dynamo current then follows, causing a short circuit, and the heat produced by the arc expands the air in the chamber and drives the two discharge points out, extinguishing the arcs and rupturing the short circuit. The discharge points then swing back, and the apparatus is ready for another discharge. In testing one of these instruments the binding posts were connected to the poles of a 1,000-volt alternator, and the two air spaces were bridged over with a small strip of tinfoil. Then, by the throw of a switch, the generator was short-circuited through the lightning guard, the tinfoil was fused, the air expanded, the discharge points were forced out of the air chamber, the arcs were blown out, and the points returned to their normal positions. After several hundred such discharges the instrument is said to have shown no deterioration.

Steam-Boiler Economy.—The general subject of steam engines and boilers was recently discussed by Mr. John M'Laren, in a communication to the Federated Institute of Mining Engineers. The author remarked that Cornish or Lancashire boilers, with a heating surface of about 14 square feet per horse-power, were displacing the cruder patterns. Tubular or water-tube boilers, largely adopted on the Continent and in America, were coming into limited use in this country. Their economy, however, he thought, was doubtful; they were given to priming, and a great disparity of results has been noted in reported tests. Mr. M'Laren thinks the locomotive type of boiler unquestionably the best and most economical steam generator in practical use. These boilers require no expensive setting, and are easily looked after. They can be stayed so as to be absolutely safe at pressures up to any practical limit; they occupy the least space of any boilers in proportion to their power; and they give an extremely high evaporative duty. There is an unreasonable prejudice against these boilers in the minds of some steam users, owing to their supposed greater wear and tear, though in practice they will be found, in the end, to cost no more for repairs than Cornish or Lancashire boilers doing equal duty. The evaporative efficiency of the different types of boilers may be stated approximately as follows:—Egg-ended boilers, 4·6lb. of water per pound of fuel; Lancashire boilers, 8lb. of water per pound; tubular boilers, 7lb. to 10lb. of water per pound; locomotive type boilers, 11lb. of water per pound—all from and at 212° Fahr. According to Mr. M'Laren, the highest economy of both boiler and engine obtained in a properly authenticated experiment is 1 I.H.P. for a consumption of 1·35lb. of coal per hour, which is about 11·75 per cent. of the theoretical capability of the fuel used.

The Chicago Exhibition.—The following amusing paragraph from the *Spectator* doubtless describes the feelings of many of our readers who are endeavouring to develop the proper amount of enthusiasm about the forthcoming "World's Fair" at Chicago: "Nothing, as a rule, can be duller to think of, or to write about, than International Exhibitions. They may have their uses, but these are not apparent, and the thought of a 'World's Fair' is apt to call up sickening recollections of the blank misgivings suffered by creatures who have wandered about in worlds unrealised, and beheld, with a sentiment akin to horror, a vast welter of 'miscellaneous exhibits.' Hope springs eternal in the human breast, and people imagine that, somehow or other, their second exhibition will not be like their first, else the promoters of such infernos would long ago have been regarded and treated as *hostes humani generis*. We do not believe that there exists a human being who, if forced to speak the truth, the whole truth, and nothing but the truth, would fail to admit that the prevailing sensation experienced during the 'doing' of any particular exhibition was one of mental and physical exhaustion of the most acute kind. The trudging through endless hot and draughty sheds, mocked by the name of 'pavilions,' and lined with huge glass cases, the miserable longing for food, never satisfied till too late, and the horrible sense of intellectual repletion which gradually grows on the exhibition goer, are remembered by most people like a hideous nightmare. Yet, somehow or other, many of them fancy that it will be different next time, that they will manage better, and that at last they will contrive not merely to see, but to enjoy, the wonders of the show. Hence it happens that exhibitions are tolerated, in spite of the fact that no sane person was ever known to obtain enjoyment thereby. Though we cannot profess to feel any enthusiasm at the thought of the Chicago Exhibition, we have no hesitation in adopting the formula used by the hero of Illinois when he desired to express a general sympathy with things which he personally disliked. On such occasions Mr. Lincoln was wont to observe, that for 'those who like that sort of thing, that's just what they like.' This is exactly our feeling towards the Chicago Exhibition. As long as we can keep away ourselves, we shall find no difficulty in declaring 'that those who like that sort of thing' will find the Exhibition 'just what they like.'"

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MAGNETISM IN IRON AND OTHER METALS.*—XLVI.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 325.*)

§161. **Bar and Yoke.**—In speaking of applications of the idea of the magnetic circuit, we may revert briefly to the arrangement of bar and yoke, first used by Hopkinson in experiments on susceptibility, and described above in §§ 58-59, Figs. 26 and 27. The function of the yoke is to make the bar form part of a nearly perfect magnetic circuit, of which the resistance of the bar itself is nearly the whole resistance. Let l_1 be the effective length of the bar, which is somewhat greater than its clear length within the yoke (since there is a gradual spreading out of the lines of induction when the bar penetrates the yoke), and let s_1 be the cross section of the bar. Let l_2 be the length of the return path of the lines through the yoke, and s_2 the cross section of the return path, which is the sum of the cross sections of the two sides of the yoke. Let N, as usual, be the number of turns of the magnetising coil, which is wound on the bar. Then, by the principle of the magnetic circuit,

$$4\pi C N = \text{Flux} \times \left(\frac{l_1}{\mu_1 s_1} + \frac{l_2}{\mu_2 s_2}\right),$$

$$= \mathsf{B}_1 s_1 \left(\frac{l_1}{\mu_1 s_1} + \frac{l_2}{\mu_2 s_2}\right),$$

where B_1 is the magnetic induction within the bar. The flux, $\mathsf{B}_1 s_1$, is the quantity which the ballistic test measures. The equation may be written

$$4\pi C N = \frac{\mathsf{B}_1}{\mu_1}\left(l_1 + \frac{\mu_1 s_1}{\mu_2 s_2} l_2\right).$$

Now H, the true magnetic force acting on the bar, is $\frac{\mathsf{B}_1}{\mu_1}$; hence

$$\mathsf{H} = \frac{4\pi C N}{l_1 + \frac{\mu_1 s_1}{\mu_2 s_2} l_2}.$$

The magnetic resistance of the block therefore virtually adds a small piece to the length of the rod—a piece, namely, whose length is $\frac{\mu_1 s_1}{\mu_2 s_2} l_2$, and the effect is that the actual magnetic force is equal to the force due to the magnetising solenoid $\frac{4\pi C N}{l_1}$ *minus* a small correction, the amount of which may be written thus:

$$\mathsf{H} = \frac{4\pi C N}{l_1} - \frac{\mathsf{B}_1 s_1 l_2}{\mu_2 s_2 l_1}.$$

This correction may be made insignificantly small by using for the yoke a material of the greatest possible permeability, and giving it an area of section very many times greater than that of the bar.†

The amount of the correction is not constant, even when expressed as an addition to the length of the bar, for μ_1 and μ_2 are functions of the magnetic state of the bar and yoke respectively, and bear no constant proportion to each other. In all that has been written regarding the magnetic circuit, μ has simply this meaning, that it is the ratio of the induction which happens to exist at the moment, to the magnetic force which happens to exist at the moment. The value of the correction depends, therefore, not merely on the magnetic force actually in operation, but on the previous magnetisation of the circuit. The correction may, of course, be very completely made by the graphic process which has been described, provided we have data from which to draw a curve of B and H for the material of the yoke.

We have spoken of this magnetic circuit as if it were wholly made up of the bar and the yoke. In fact, however, there is another constituent, the importance of which will be more apparent presently. This is the joint at each end of the bar; between the bar and the yoke. We shall see immediately that a joint, that is to say, a discontinuity in the substance of the magnetic circuit—even when there is no perceptible space separating the parts—interposes some resistance. Its effect is equivalent to that of a very narrow air-gap.

Acting like an air-gap, each joint in the circuit tends to shear over the curve of magnetisation, and one effect is that the residual magnetism of the circuit is reduced. This is a rather serious objection to the use of the yoke for determining the permeability of soft iron.

§162. **Magnetic Resistance of Joints.**—The fact that a joint offers magnetic resistance seems to have been first noted by J. J. Thomson and H. F. Newall, who found that when an iron bar was cut in two, and the pieces were put in contact, the susceptibility of the bar was considerably reduced.*

In the following experiments† a tolerably full examination was made of the influence of a joint in adding magnetic resistance to an iron bar, both when the surfaces of the joint were placed in simple contact, and when they were pressed close by externally applied force. The bar was a turned piece of wrought iron, 0·79 cm. in diameter, and it was tested by the ballistic method within a yoke which allowed a clear length of 12·7cms. of the bar to be exposed. Over the whole of this length a magnetising coil was uniformly wound: the magnetising forces which will be stated below are the forces due to this coil. The area of cross section which the yoke provided for the return of lines of induction outside the bar was more than one hundred times greater than the cross section of the bar; nearly the whole magnetic resistance of the circuit was, therefore, that of the bar itself, and of the joint, or joints, in it. The magnetisation of the bar was tested by observing the transient current induced in a small secondary coil, wound at the middle of the length, when the current in the magnetising coil was reversed. Successive observations were made in this way, with magnetising currents that were progressively increased, to determine in each case a curve connecting B in the bar with the magnetising force of the coil.

The bar was first tested without any cut, and then when cut in the middle into two parts, the ends of which were carefully scraped to form true planes before being put into contact. The truth of the surfaces which formed the joint was tested by comparison with a Whitworth surface-plate. Notwithstanding the closeness of contact which this procedure ensured, the joint was found to offer a very appreciable amount of resistance, as the following figures will show:—

Table XXVI.—*Influence of a smooth joint in reducing the magnetic induction in an iron bar.*

Magnetising force due to solenoid.	Magnetic Induction B.	
	Bar uncut.	Bar cut in two pieces with surfaces of the joint faced to be true planes.
4	3,950	3,000
6	6,900	5,300
8	9,250	7,400
10	10,900	9,150
15	13,250	12,000
20	14,300	13,500
30	15,200	14,900

§163. **Calculation of the Equivalent Air-gap.**—The influence of a joint in adding magnetic resistance may be conveniently expressed by calculating the width of an air-gap which would have the same resistance, assuming the permeability of the metal itself to be wholly unaffected by cutting. The width of the equivalent air-gap is readily found in the following way‡:—

Let H_1' be the magnetising force due to the solenoid when the bar is uncut, and H_2' the magnetising force due to the

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† See Hopkinson, *Phil. Trans.* 1885, p. 458.

* *Proc. Camb. Phil. Soc.*, 1887.

† "On the influence of a plane of transverse section on the magnetic permeability of an iron bar (by the writer and W. Low)."—*Phil. Mag.*, Sept., 1888.

‡ In the Paper from which these experiments are quoted an erroneous procedure was followed in calculating the width of the equivalent air-gap. The error had the effect of making the gap appear to diminish in thickness as the magnetisation was strengthened. The figures given here are corrected.

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solenoid when the bar is cut, both for the same value of **B**. Let l be the length of the bar, and s its area of cross section. Let x be the width of the air-gap equivalent in magnetic resistance to the joint. Then, by the principle of the magnetic circuit

$$H_1' l = \frac{B l}{\mu},$$

and

$$H_2' l = \frac{B l}{\mu} + B x.$$

Since **B** is the same in both cases, μ is the same. Hence,

$$B x = H_2' l - H_1' l,$$

and

$$x = \frac{(H_2' - H_1') l}{B}.$$

To find x, we have therefore to draw curves of **B** and H_1' and of **B** and H_2', and measure the horizontal distance from one curve to the other, that is to say, the difference of H' for the same value of **B**. The quantity $H_1' l$ is the magnetomotive force that suffices to produce the induction **B** when the bar is uncut. The quantity $(H_2' - H_1') l$ is the additional magnetomotive force that is required to force the same induction **B** through the joint.

In Fig. 134, the curves are drawn for the experiment which has just been quoted, and the values of $H_2' - H_1'$ are represented by the slightly curved line at the side of the figure. This line is not far from straight—which implies that the width of equivalent air-gap is not far from constant throughout the range of

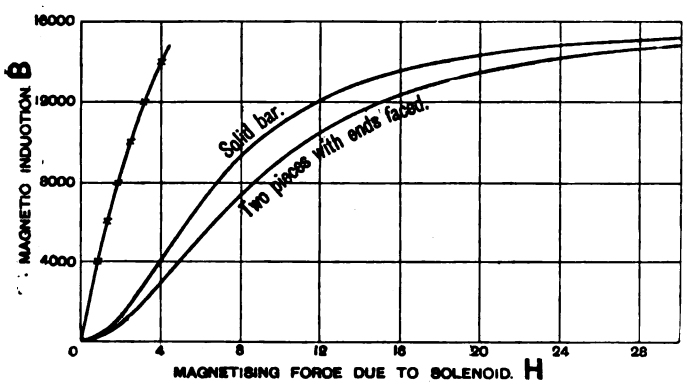

Fig. 134.—Influence of a Smooth Joint on the Magnetic Resistance of an Iron Bar

values of **B** with which the experiment deals. This curve does, indeed, incline slightly outwards at the higher values of **B**, implying a greater width of equivalent air-gap in the region of strong magnetisation; but it may be questioned whether this slight deviation from straightness may not be due to errors of observation. A very slight error in the value of **B** in one or other of the two curves would suffice to account for it; and in another precisely similar experiment, made with another bar, the line showing values of $H_2' - H_1'$ actually bends slightly *inwards* at high values of **B**. It appears, then, that the joint is equivalent, in magnetic resistance, to a narrow gap of air, the width of which is at least not far from constant. The following are the widths of this gap calculated for the experiment of Table XXVI. and Fig. 134.

B.	Width of equivalent air-gap in centimetres.
4,000	0·0026
6,000	0·0030
8,000	0·0031
10,000	0·0031
12,000	0·0035
14,000	0·0037

The corresponding quantities in another and quite independent experiment, made with a different iron bar, were:—

B.	Width of equivalent air-gap in centimetres.
6,000	0·0043
8,000	0·0041
10,000	0·0036
12,000	0·0030

In this case, as in the other, the ends of the bar after being cut were carefully brought to the condition of true planes.

We may take a width of 0·0033cms. to represent fairly the equivalent gap in the first case, and 0·0036cms. in the second. These figures agree with one another as well as the circumstances of the measurement would lead one to expect. The equivalent gap is not very wide, but it is difficult to believe that the surfaces of the metal were actually separated by even this narrow space. It seems more probable that the magnetic resistance of the joint is due in part to a diminished permeability in the metal itself at and close to each surface, and this conjecture receives some support, as may appear later, from the theory which ascribes the process of magnetisation to the arrangement of molecular groups.

§ 164. Influence of Compression on the Magnetic Resistance of a Joint.—Other experiments in the same series* were directed to examine how the magnetic resistance of a joint is affected when the surfaces are pressed into close contact. The method of the yoke was still employed; the yoke was placed so that the bar stood vertically, and compression was applied to the bar by means of a weighted lever at the top, and a stop at the bottom, as in Fig. 97, § 122. In experiments of this kind it is, of course, necessary to remember that the permeability of the metal itself is changed by compressive stress; the influence of the joint is to be tested by comparing the resistance of the cut bar under pressure with the resistance of the uncut bar under equal pressure. It was found that the effect of pressure is to lessen the magnetic resistance of the joint, so much so, indeed, that when the surfaces composing the joint are true planes, a tolerably strong compressive stress almost wholly destroys the resistance of the joint, and restores the divided bar all but perfectly to the magnetic condition of an uncut bar. This effect was produced almost completely by a stress, the intensity of which was 226 kilogrammes per square centimetre. Under this load a curve of **B** and H' taken for the cut bar was practically indistinguishable from the curve taken for the solid bar. Smaller loads only reduced the resistance of the joint without making it disappear, and a progressive reduction of the resistance could be traced as the loads were increased. The following table gives the values of **B** which were observed in an iron bar, first when solid and then when cut in two parts with faced ends, under various stresses, the magnetising force due to the solenoid being brought to the same value (5 C.-G.-S. units) in each case. This magnetising force was applied after each load had been put on.

Table XXVII.—*Influence of compressive stress in reducing the magnetic resistance of a joint.*

Stress in kilos. per sq. cm.	Magnetic Induction **B**, produced in each case by a magnetising force in the coil (H') of 5 C.-G.-S. units.	
	Before Cutting.	After Cutting.
0	5,600	4,700
56·5	5,400	4,670
113	4,700	4,200
169·5	4,050	3,800
226	3,650	3,650

Here, under the highest stress, the disappearance of the joint's resistance was complete for a magnetising force of 5 C.-G.-S., but under stronger magnetising forces it was hardly so perfect.

In connection with these results it may be noted that the magnetic traction, $\left(\frac{B^2}{8\pi}\right)$ amounting, as it does, to less than 1 kilogramme per sq. cm., when **B** is 5,000, is insignificant in comparison with the stress produced by external loading.

* *Phil. Mag.*, September, 1888, p. 278.

(To be continued.)

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THE OERLIKON THREE-PHASE ALTERNATOR.

The electric transmission of power for industrial purposes has now become an every-day affair, and, owing to the distances which in the majority of cases separate the waterfalls from the places where their energy is to be utilised, high pressures are necessary. Owing to the ease with which they lend themselves to transformations of pressure, and for other reasons, alternating currents are eminently adapted to the purpose, and when these currents are of the multiphase character, satisfactory motors are also forthcoming. The Oerlikon Works, which have for long made a speciality of transmission of power installations, are about to lay down several plants on the multiphase system, devised by Mr. C. E. L. Brown.

In Fig. 1 we have a general view of a 300 H.P. Brown "multiphaser," running at 150 revolutions. The armature circuits are arranged to give three alternating currents lagging 120deg. one behind the other. Each of the three circuits of the machine is wound for a pressure of 50 volts and a current of 1,400 amperes. The current output being large, rubbing contacts have been avoided by making the armature stationary and the field-magnets revolve. The armature conductors are 29mm. in diameter, and consist of massive bars of copper, insulated inside asbestos tubes, and buried in holes punched out of the iron close to the internal periphery. Foucault currents, which would attain enormous values in such large copper conductors, if they were arranged in the ordinary way, are by this device avoided; in fact, experiments made with "buried" conductors, 50mm. in diameter, did not show that any power was lost by Foucault currents. This method of arranging the armature conductors is mechanically strong, and, as it enables asbestos to be used as an insulator, results in an armature which is absolutely incombustible. Moreover, the reduction in the air space, and the consequent improvement of the magnetic circuit, reduces the exciting current.

Corresponding to the 32 poles of the field-magnet, each circuit of the armature has 32 copper bars, connected in series by transverse pieces. There are, therefore, in all 96 (3 × 32) bars on the armature. The three circuits are joined up to each other in a manner similar to the three circuits of the Thomson-Houston arc machine. The armature core is surrounded by a cast-iron frame, and the whole can be moved along the bed-plate for cleaning and other purposes, leaving the field-magnet open to view, as shown in Fig. 2.

The exciting circuit is coiled round a sort of cast-iron pulley. Two steel rims, each armed with 16 horns forming pole-pieces, are bolted on to the pulley, one on either face, in the manner shown in detail in Figs. 3 and 4. This arrangement permits of the maximum utilisation of the magnetic flux, and both the copper and the exciting current are reduced to a minimum. The construction of a field magnet of this type is very simple, the 32-pole magnet being only in four separate parts, an inestimable advantage in a piece of moving mechanism subject to heavy stresses.

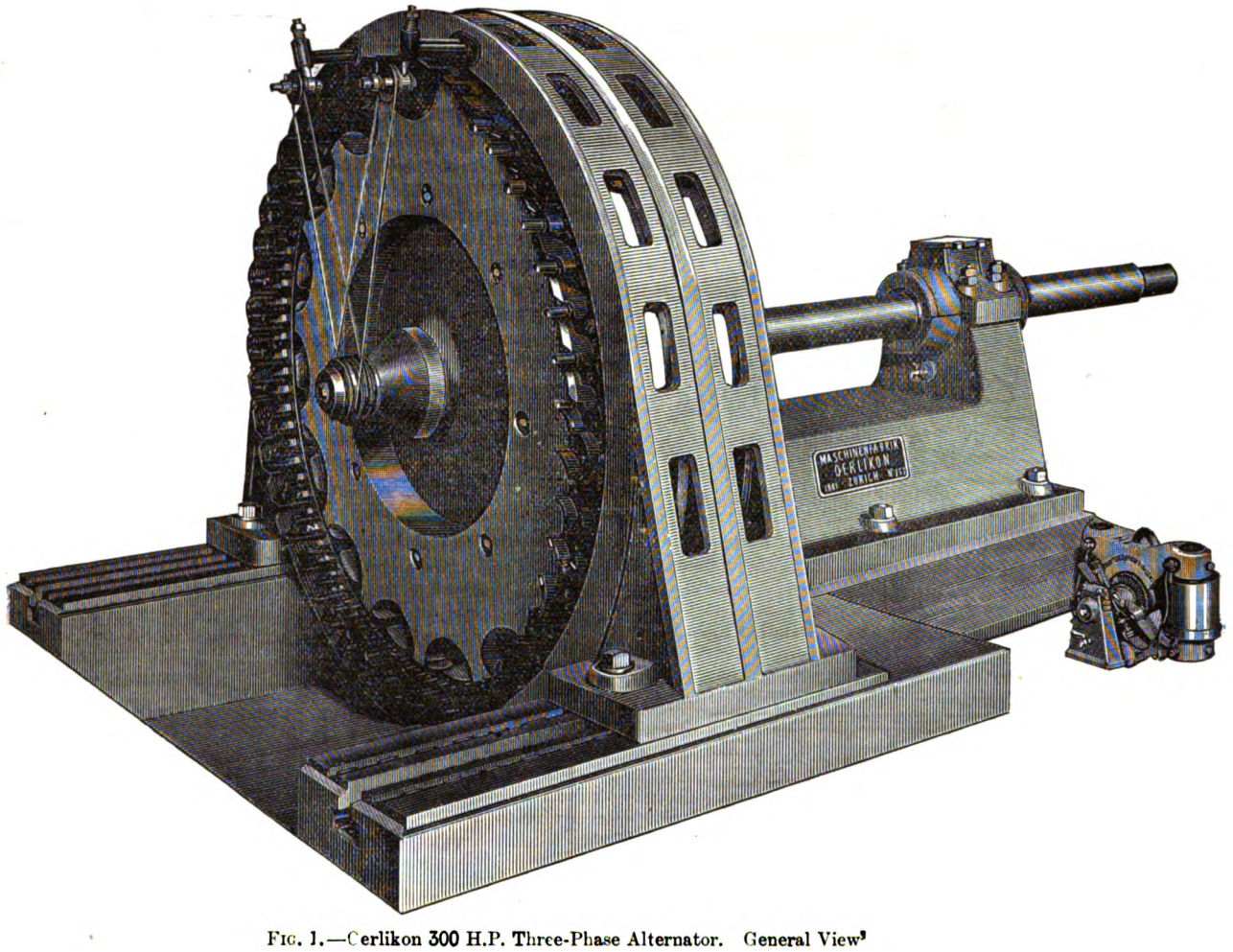

FIG. 1.—Oerlikon 300 H.P. Three-Phase Alternator. General View.

The exciting current is taken to the field magnets by means of two metallic bands, each of which passes round a grooved ring on the spindle, and round a pulley connected to a terminal. (See Fig. 1.) The armature is overhung, the massive spindle being carried on a double bracket bolted to the bed-plate.

A machine of this type can work equally well as a synchronising motor, but it differs from an ordinary alternate current motor, inasmuch as it can be made to start without difficulty.

A few figures may not be without interest. The total weight of copper on the field magnet is 300 kilogrammes; that is to say, a fraction of the copper usually required for other machines of the same size. To excite the machine so as to give 50 volts on open circuit, only 100 watts are required; that is to say, one-twentieth per cent. of the output. At full load, owing to the reaction of the armature, this amount is slightly increased, but it never exceeds a fraction of one per cent. At

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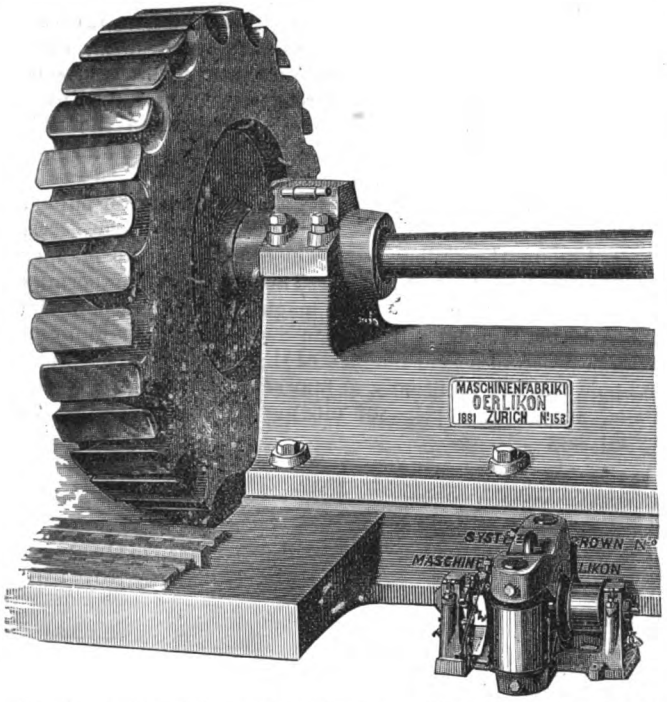


FIG. 2.—Oerlikon Three Phase Alternator. View of Field Magnet with Armature removed.

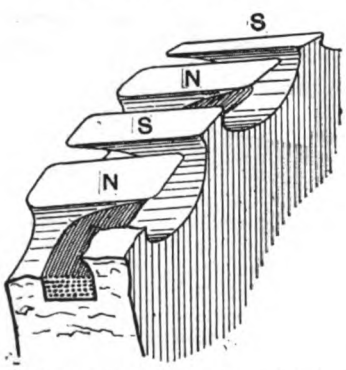


FIG. 3.—Oerlikon Three Phase Alternator. Detail of Field Magnet.

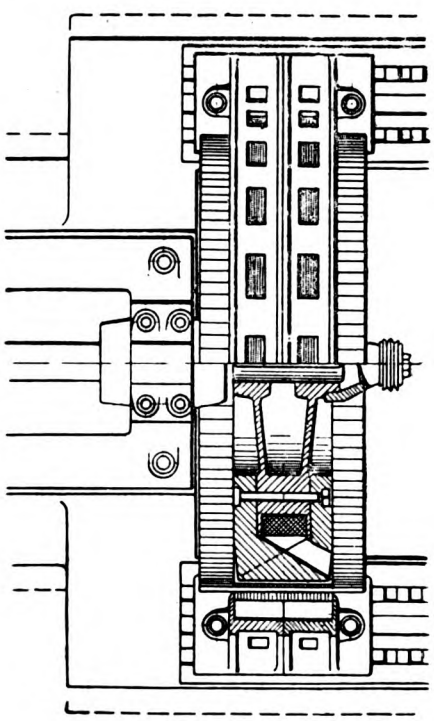


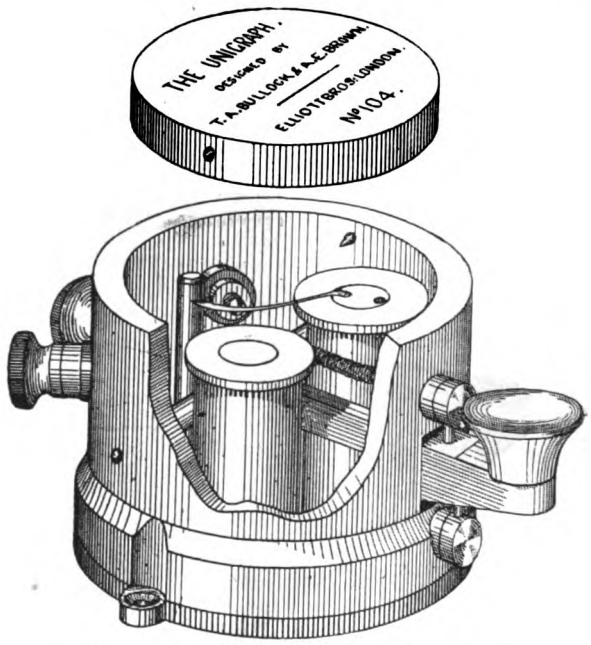
FIG. 4.—Plan and Half Section of Dynamo, showing Construction of Field Magnets.

full speed, and with normal volts, the friction losses amount to 3,600 watts, about 1·6 or 1·7 per cent. of the maximum output. The C^2R loss in the armature at full load is 3,500 watts. Adding all these losses up, we still have a commereial efficiency of 96 per cent. With such small losses the heating is, of course, quite negligible. The total weight of the machine without bed-plate is 9,000 kilogrammes.

The Oerlikon Works have completed, or have in the course of construction, several dynamos of this type. First of all comes the Lauffen-Frankfort transmission plant. Machines are also building for 10 kilometre transmission at Heilbronn, and at Zürich ; while three generators with vertical spindles, for coupling direct to turbines, and two motors with horizontal spindles are to be employed to drive the whole of the machinery at the Oerikon Works from a waterfall 23 kilometres distant.

THE UNIGRAPH.

An ingenious little telegraph instrument, combining in one small and compact space a sending key, and a loud speaking sounder, is being made by Messrs. Elliott Bros., under the name of The Unigraph. The accompanying illustration represents the instrument full size, the circular armature being removed, and the side broken away to show the interior. The base



The Unigraph, with Hollow Disc Armature removed.

is of iron, and acts as a yoke. The armature, or keeper, forms one of the special features of the invention. It is in the form of a hollow disc, instead of the bar or tube generally employed. The form and thickness of this disc is so arranged that an unusually loud and clear sound is given for a small current. The disc is mounted to rock on centres, and is pushed away from the magnets by a light spring between them, as shown in the illustration. The outer box is only 2 inches in diameter, and stands $1\frac{3}{8}$ inches high. It is suggested by the inventors that this form of instrument is particularly suitable for students and learners, and for use in military telegraphs, on account of its simplcity and clear speaking.

The Society of Arts and the Chicago Exhibition.—Forms of application for space, and prospectuses, with detailed information, will not be issued till October; but, in the meantime, intending exhibitors can apply to the Secretary of the Society of Arts, and their names will be noted at once, with a view to their receiving early copies of the prospectus, when ready.

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EXPERIMENTS WITH CONDENSERS.*

BY MAURICE LEBLANC.

I experimented with two types of condensers, namely, some made of paraffined paper and intended for medium pressures up to 2,500 volts, and others made of ebonite.

The first, constructed by M. Labour, gave such singular results, that they seem to me worthy of being placed on record. Paper of very mediocre quality and common paraffin heated to 70°C. were employed. Their capacity, as measured in the ordinary way, showed that the dielectric possessed a specific inductive capacity of about 8, but the residual discharge was about one-fourth of the first discharge. If their capacity was measured by applying an alternating current of 75 ∿ and known strength, and noting the difference of potential at the terminals, it was found that the apparent specific inductive capacity was one-third less than that previously determined. Finally, when they were subjected to the continuous action of an alternating potential difference of between 1,500 and 2,000 volts, they quickly heated, the paraffin melted, the condensers began to "hum," and if the experiment was not terminated the condensers were soon destroyed.

I at first attributed this result to the inferior quality of the material employed, but no sensible advantage was gained by using the best paper and paraffin. Endeavouring to explain the phenomena observed, it occurred to me that, paper being an organic substance, each of the constituent cellules enclosed an extremely minute drop of liquid. Similarly, the paraffin might contain traces of the sulphuric acid which had been used to purify it. We were, therefore, dealing with the dielectric whose properties were investigated by Poisson, namely, a perfect dielectric studded with conducting spheres. The high specific inductive capacity and the heating when in operation were thus explained.

It seemed probable that if the paper were previously heated for several hours in paraffin at the temperature of dissociation of this substance, the organic constitution of the paper would be destroyed, and the paraffin would give up any trace of acid that it might contain. Experiment confirmed this idea. The paper, on being taken out of the paraffin, had completely changed in appearance, increased in thickness, and every trace of fibre had vanished. The specific inductive capacity of the dielectric had been reduced to 2, 5, 6; the residual discharge had become insignificant, and condensers made of this material no longer got hot. But this method of preparing the paper is very expensive, owing to the large amount of paraffin which is decomposed. Moreover, the sheets sticking to one another, it is necessary to keep them hot in order to separate them as required, which is a difficult and delicate operation, and results in a great increase in the cost of construction.

While these condensers were being made several experiments were carried out on the first ones, which, being considered defective, were extremely badly treated, and had often to withstand a potential difference of 4,000 volts. Later on, requiring to measure the capacity of some of these, I was surprised to find it much less than was anticipated. The specific inductive capacity of the dielectric had become 2·56. As it seemed logical for the heating effect to have also diminished, the experiment was tried and fulfilled anticipation. These condensers, which were so defective at the commencement, no longer heated, and had become excellent. To clear the matter up completely a second set of similar condensers were made, and were kept at work for several days, their increase of temperature being carefully noted. Everything fell out as was expected. The condenser heated less every day, and at the end of ten days of nearly continuous experimenting, at a pressure of 1,500 volts, they became equal to the first lot. It follows from this that excellent results may be obtained with condensers of paraffined paper, and that one need not trouble oneself about the quality of the material so long as it undergoes a process of formation as described. Condensers must not be put into operation without careful attention, and they must be cut out of circuit as soon as they heat up sensibly.

The following, by-the-way, is a practical and easily observed rule:—A condenser which works without emitting any sound whatsoever is in no danger; as soon as it begins to vibrate it is in danger.

It is easy to understand that that which the action of heat was able to effect in a few hours (about three on an average) the electric displacement which was taking place among all the conducting particles enclosed in the mass was able to effect slowly. This brings into prominence a property of alternating currents which is now generally recognised, namely, that their action on dielectrics is beneficial rather than deleterious. It is easy to show this. Under the influence of steady potentials all the conducting molecules confined within a dielectric take up a definite position once for all, like the anions and cathions of an electrolyte. These molecules tend to move towards one another, which they can only do by opening a path through the dielectric and changing its constitution. Under the influence of alternating potential differences, there is electric displacement in the heart of the conducting mass itself. Now, I have never been able to pass an alternating current through a liquid, even when the current density was very low, without bringing about a trace of liberation of gas. Is it not logical to suppose that the same thing takes place in the conducting molecule itself, and that the gaseous products never entirely recombine? They could not, indeed, do so, for there is no system of transformation having an efficiency of unity. In this way can be explained the fact that all imperfectly conducting substances which can only transmit electricity after the manner of electrolytes, and which are confined in a dielectric, are destroyed in time under the influence of alternating potential differences before the mass of the dielectric has been sensibly impaired by the mutual action of these molecules.

Ebonite condensers gave entire satisfaction. The capacities, measured by the ordinary methods, or by means of alternate currents, were the same; the residual discharge was insignificant. Lastly, they did not heat. The tinfoil was fastened on to the ebonite sheets either with chatterton or "arkanson," melted and placed on with a brush. The ebonite sheets were kept on a hot plate until they became soft and very supple. The tinfoil was applied by means of an ordinary hot iron. Chatterton seemed to be the best cement. Condensers made in this way were regular solid planks. The thinnest ebonite that I was able to procure was ·2mm. thick. I was not able to break this sheet down under a pressure of 11,000 volts—the highest obtainable.

Celluloid also yielded good results as a dielectric, but I gave up the idea of employing it owing to its inflammability, a spark being enough to set it alight. The variety known by the name of American linen does not, however, possess this defect to the same extent, and if the experiments on this material were not continued it was only because I was finally able to get ebonite at a very low price; that is to say, at 6·5frs. the kilogramme when ·5mm. thick, and 12frs. the kilogramme when ·2mm. thick. It was this ebonite which I tested.

When the pressure applied to a condenser is raised considerably, a *frizzling* noise is heard, and an odour of ozone is at the same time perceptible. In my experiments an inductive coil was made use of, the iron rod of which vibrated naturally twice as rapidly as the current. The *frizzling* noise which was heard seemed always to be two octaves higher than the note given out by the rod. I attributed it to lateral discharges due to the higher harmonics of the current. If this be so, it should be possible to suppress it by increasing the space separating the edge of the tinfoil from the edge of the dielectric. This was found to be possible. It is, however, necessary that this distance should be at least 5cm. if one wishes to avoid all rustling noise when the pressure exceeds 11,000 volts on the electrometer.

* Extract from a Paper entitled "De l'Application des Courants Alternatifs à la Transmission du Travail," read before the Soc. Inst. des Electriciens, July 1, 1891.

ON THE DETERMINATION OF THE MAXIMUM CONDUCTIVITY OF VERY DILUTE SOLUTIONS OF COPPER SULPHATE.*

BY P. SACK.

Arrhenius theoretically proved that the conductivity of an electrolyte must possess a maximum value at a certain temperature. For phosphorous and phosphoric salts this maximum lies at 54deg. and 73deg. respectively, as he found experimentally. The author conducted similar investigations for three very dilute solutions of copper sulphate, and found the maxima to be as follows:—

Strength of solution per cent.	Temp. maximum conductivity.
·321	94°C
·500	95°C
·642	96°C

The resistances were measured by Kohlrausch's method with a Wheatstone bridge, an alternating current, and a telephone. The resistance was prepared as follows:—Two egg-shaped glass vessels were connected underneath by a glass tube, and each had a small tube fixed into its side. These served to fill the glass vessels, and after this was done they were sealed up. Platinum wires were fused through the upper part of the vessels, and were provided with concave cup-shaped electrodes.

With this arrangement no movement of the electrodes is possible, the degree of concentration cannot be affected by evaporation, and the liquid can be heated above its boiling point. In the latter case an explosion of the glass must be guarded against. The vessels were made of potassium glass, and the warming was effected by an air bath.

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THE POSTAL TELEGRAPH ESTIMATES.

A great part of last Saturday's sitting in the House of Commons was taken up with a discussion of the Postal and Telegraph estimates for the year. Probably no Vote that comes before the House is less open to criticism than that of either the Post Office or the Telegraph services, yet hardly any receive more attention. The reason is not far to seek. A surplus of from three to four millions is, so to speak, ready to hand, and anybody who has a hobby to ride or a grievance to air is eager to demand his share of the good things going. Why the Post Office revenue, much more the Telegraph, should be regarded as profit and available as surplus, whilst that of the Custom House and other taxing departments of State is treated as too sacred to be touched, is somewhat unintelligible. Certainly, whatever profits the Post Office or the Telegraphs may be able to cast into the Treasury are a relief to the general taxation; and surely no form of taxation could be less vexatious or less burdensome than the charges on letters and telegrams. Already these services are as cheap in this country as in most, and cheaper than in many; while as regards efficiency and expedition, no other country can rival this. Until recent years, the profits derived from Postal business were accepted as aids to national revenue — in other words as relief

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of taxation; but latterly, an outcry has been raised against this source of income, not, however, because of its demerits, but because certain ingenious persons are ever ready to find other ways of disposing of the money than putting it into the National Treasury.

As regards its effects on the Postal revenue, the activity of these critics is of no great consequence. Mr. RAIKES can well afford to appease their appetites by sacrificing a few hundred thousand pounds now and again; and the service has certainly benefited by the manner in which he has disposed of the money. But it is quite a different matter when similar demands are made upon the Telegraph revenue. In public estimation the two services are one; and the result is that every penny saved out of Telegraph earnings is subject to the same extravagant demands as are the profits of the Postal Service. This year there has been a surplus for the first time since the introduction of the sixpenny rate—a surplus, if we rightly understand the POSTMASTER-GENERAL's statement, even after paying the interest on capital. No sooner is this point reached than a serious effort is made to appropriate the margin, and we are sorry to notice that some sort of encouragement was given to the raiders last Saturday afternoon. For many years past the fact that the State Telegraph Department was carried on at a loss protected it from encroachments of that kind, and was, perhaps, the only valid excuse remaining for keeping the accounts separate from those of the Postal Service. But now that a remunerative period has set in, its connection with the richer department threatens to work to the disadvantage of the Telegraph, by bringing it within range of the Post Office reformer. This class of person is possessed with the idea, as enunciated by Mr. SHAW-LEFEVRE the other day, that "there never has been any improvement made in the service at a considerable expense which had not ultimately led to an increase of the revenue at least equal to the cost." The telegraphs were acquired "at considerable expense," and if their acquisition may be regarded as an "improvement in the service," Mr. SHAW-LEFEVRE's statement is contradicted by the result, as he himself admits a little further on, But if the Post Office is to be credited with the improvement, it is high time it took up the burden, and relieved the Telegraph of the financial difficulties it will again have to encounter if any further demands upon its resources are yielded to.

In a general way we do not attach much importance to that section of Post Office critics represented by Mr. HENNIKER HEATON; but he has suddenly become a serious danger to the Telegraph Service by reason of a reply which he elicited from the POSTMASTER-GENERAL on the discussion of the Telegraph Vote. The member for Canterbury is apprehensive that the Telegraph Service may soon become what the Post Office is, a profit earning department; and as a means of averting this peril he entreated MR. RAIKES to "carry out as early as possible the reform of having an address not exceeding eight words sent free." To this the POSTMASTER-GENERAL, without committing himself to any definite proposition, expressed an opinion that some relaxation in respect to addresses was desirable, and stated that he would be glad if at some future time the Treasury might allow them to be put upon a rather more liberal footing. If we may take this as a deliberate announcement it can mean little less than that we are at some not distant day to have a 20-word in place of the 12-word tariff. It will be a long time before the revenue can really afford such a sacrifice, or the existing plant bear the strain of extra work such as that would involve. The normal telegram at present averages 16 words, for which 8d. is paid. It follows that the public, being willing to spend 8d. on each telegram, will spend nearly as much if the minimum of 12 words were increased to 20. That is to say, the average telegram would then contain nearly 24 words. If any one doubts this prediction we would remind him that the average length of the telegram under the old tariff, with free addresses, exceeded 30 words, although the cost was 1s. Notwithstanding all this, Mr. HENNIKER HEATON is not the man to allow his occupation to go by default, and having now in prospect another brilliant reform, for which he may some day take credit, he will never cease from troubling until the question is settled one way or another for good and all.

The sooner, therefore, it is gone into the better. So far as the public is concerned we believe that, while taking the fullest advantage of every concession, it is content with the tariff as it stands. That tariff is consistent and intelligible, a charge being made for every word signalled. If it can be shown that the finances will bear it, no one can object to an extension of the 12 words limit, though it must be clearly understood what such a privilege represents in money; and on no account should the Telegraph Service be starved in any way for that object. But, unfortunately, Mr. RAIKES's language, if correctly reported, goes beyond a mere extension of the limit, and practically concedes all that has ever been said against taxed addresses. Even if the 12 words limit were enlarged to 20, it would leave the clamour for free addresses unappeased in the face of what was officially stated last Saturday. We can only hope that the words let fall then will be unsaid so soon as the figures are gone into. All that we need say on that part of the subject at present is that there is no stopping place between taxed addresses and free addresses. It could easily be shown that there is no logical reason for taxing the sender's address, while the addressee's goes free; and Mr. HENNIKER HEATON well knows that to create two limitations—two sets of counting—in the same message would be so inconvenient to the servants of the Telegraph Department that enfranchisement for both addresses altogether must speedily follow.

AN IMPERIAL STANDARD OF LIGHT.

A good deal of stir was made by electrical engineers some years ago for a better standard of light than the Parliamentary candle. The only practical result brought about was the development of the pentane lamp into its present state of excellence. The suggestions about which most fuss was made were the most impracticable, and it was doubtless thought by the Board of Trade that the agitation was but part of the enthusiasm with which electric light was received. The delay was reasonable, not only that matters might settle down before attempting to decide whether a new standard was really wanted, but to allow time for the construction of some simple and thoroughly trustworthy standard. The Gas Companies have now taken the matter up again, and they are driven to this by the zeal with which the County Council is enforcing the regulations as to illuminating power of the gas supplied. They protest against the absence of any standard of the photometers which are used against them, and the Sanitary and Special Purposes Committee allude in their recent report to this, and refer to the strong representations which they have made to the Board of Trade as to the necessity of amending the Gas Acts. In 1881, a Photometric Committee, appointed by the Board of Trade, reported adversely on the existing standard, and suggested one which was trustworthy. Since that time experiments and observations made under the direction of the Royal Society, of the Metropolitan Board of Works, and of other bodies, have shown that the standard of light suggested by the Committee of 1881 was a satisfactory one.

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At the meeting of the London County Council, last Tuesday, the Sanitary and Special Purposes Committee presented a report on the subject of a proposed amendment of the law relating to testing of gas in the Metropolis. They say that at various times they have reported to the Council the steps they have taken for obtaining an amendment of the law in relation to the standard of light. The Acts which regulate the gas supplied to London by the principal Gas Companies require that the illuminating power of gas shall, when consumed at the rate of 5 cubic feet per hour by means of a standard Argand gas-burner, be equal in intensity to the light given by 16 sperm candles, six to the pound, each burning at the rate of 120 grains per hour. The standard, says the Committee, is a most unsatisfactory one, owing to the great variation that inevitably occurs in the candles themselves, and, to some extent, in the method of burning them. This uncertainty has been recognised for many years past by all the authorities who are engaged in the manufacture or supervision of gas, and upwards of ten years ago the Board of Trade appointed a Committee, which reported adversely on the existing standard. Since that time many efforts have been made to obtain the substitution of a more satisfactory standard, and the Council has for the past two years been in frequent communication with the Board of Trade on the subject. At the request of the Board, the Council caused to be prepared clauses and schedules for insertion in a Bill, which the Committee understood was to be introduced by the Board for giving effect to the Council's views. After giving these clauses very careful consideration, the Board of Trade thought that the matter was one with which the Council might usefully deal, so far as the question relates to the London Gas Companies. The Board of Trade have undertaken to appoint a Scientific Committee to consider what the standard of light should be; and they ask if the Council would be prepared to bear the expense of such a Committee. The Sanitary Committee were not prepared to advise the Council to bear the cost of this Committee. In the first place, they remarked, the settlement of the standard of light is an Imperial and not a local question; and, in the second, it is questionable if the Council has power to expend money for the purpose. They recommend—"That a Bill be introduced by the Council in the next session of Parliament for substituting a more exact standard of light for that now prescribed by the principal Gas Companies' Acts; and that it be referred to the Parliamentary Committee to take the necessary steps for this purpose." The recommendation was agreed to without debate.

The suggestion that the County Council should spend money in settling a standard of light is a remarkable one. The Board of Trade seem to think that there is no limit to their activity, and because they are ready to meddle with all sorts of matters they only need a little encouragement to carry out work which is most distinctly part of the duties of the Board themselves. A standard of light must, sooner or later, be prescribed, and this means that some kind of lamp or other source of light must be legalised, and, when legalised, the standard candle—for the name will in all probability survive—will be an Imperial standard, like the pound or the yard.

It is true that the Electric Lighting Acts have been modelled after the Gas Acts, and in several cases important sections have been taken *en bloc*, but the fact that a certain (or uncertain) candle is mentioned in them does not confine the matter to an amendment of these Acts. A standard of light is wanted as a standard by which sales may be effected; whether of gas which shall under special circumstances yield a light which shall be measured by this standard, or of burners or glow-lamps which, with a certain quality of gas, or with a certain current, shall give a certain light. The present candle serves only to define the quality of gas which is delivered by the Gas Companies. It was never set up as a standard to which any buyers or sellers could refer. The recommendation which was agreed to by the County Council appears to refer to an amendment, for it proposes to substitute a more exact standard for that now prescribed. The matter should be dealt with under the Weights and Measures Acts, and should be taken under the patronage of the Standards Department rather than that of the Gas Referees.

THE FRANKFORT EXHIBITION.—VI.

(FROM OUR SPECIAL CORRESPONDENT.)

The firm of C. and E. Fein, of Stuttgart, has a most extensive exhibit, of which we give some illustrations below. Fig. 1 shows one of their two-pole machines driven by belt from a single-cylinder vertical engine. The massive field magnets are cast in one piece with the bed-plate; the air space is very small, one layer of wire only being wound on the armature core. Figs. 2 and 3 illustrate two other forms of dynamos manufactured by the firm, and Fig. 4 shows a machine coupled direct to a two-cylinder vertical engine. The dynamo represented in Fig. 2 is a multipolar compound-wound machine. Standard sizes are constructed to give 7, 10, 15, 24, and 36 kilowatts, the number of poles varying according to the output from 4 to 8. Fig. 3 shows the internal pole dynamo manufactured by the firm, the outside guards which protect the windings being removed. In the larger machines of this type a special arrangement is used for ensuring that all the brushes shall simultaneously be brought down upon and removed from the commutator. The 15 kilowatt machine shown (136 amperes × 110 volts) weighs about $1\frac{1}{4}$ tons, and its length, height, and breadth are respectively, 4ft. 4in., 2ft. 9in., and 2ft. 2in. The speed for this size is 500 revolutions per minute, the rotating magnet having four poles. Owing to the low speed

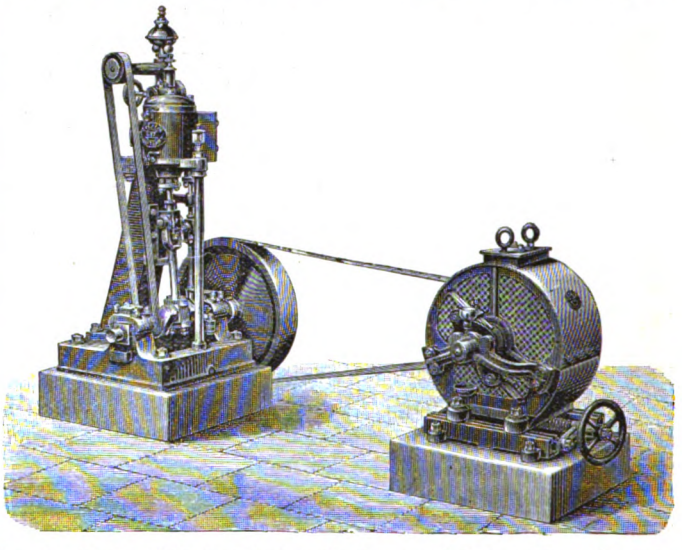

FIG. 1.—Single Cylinder Vertical Engine coupled to a Two-pole Fein Dynamo.

this type of machine is very well adapted to direct driving. They are made in six sizes, from 6 to 46 kilowatts, the speed of the latter being 280 revolutions per minute. The single cylinder engine (Fig, 1) is built in eight sizes, the diameters of the cylinders increasing from $3\frac{1}{2}$in. in the smallest, indicating 5 H.P. at a pressure of 115lb. to the square inch, and 375 revolutions per minute, to 12in. in the largest, giving 62 H.P. at the same pressure, and 170 revolutions per minute. The double cylinder machine (Fig. 4) is made in four sizes, indicating from 36 to 100 H.P. at a pressure of 140lb. per square inch. The speeds of these engines range from 600 to 350. They are fitted with a very sensitive form of governor, which regulates the speeds so well that the difference between the number of revolutions when running light and at full load does not exceed 1 or 2 per cent.

The equipment of the electric lighting waggon (Fig. 5) is very complete. In the middle is a vertical tubular boiler of about 57 square feet heating surface, built for a pressure of about 103lb. to the square inch, but worked usually only at about 73lb. It is supported on the waggon frame, which is constructed of wrought-iron. The boiler tubes are arranged so as to be easily removed for cleaning and repair. The wheels are also of wrought-iron, with broad tyres, to allow of the passage of the conveyance over soft or muddy roads. Under the waggon are the coal box and water tank, the water being heated, before entry into the boiler, by the exhaust steam. At the back of the waggon is a

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single-cylinder steam-engine. By means of a specially constructed distributing valve motion, governed by a delicate regulator, the machine can be made to run at nearly the same speed at full load and at no load. The lubrication of the bearings and all moving parts is done automatically, and an eccentric on to the crank-shaft works the pump for supplying the water to the boiler, and there is a hand wheel for bringing the crank past the dead points. The dynamo is bolted to a slab of wood, and is so placed as to be easily accessible from all sides. It is driven by a belt, which can be adjusted to the necessary tightness by a hand wheel, moving the dynamo backwards and forwards. The dynamo is compound-wound for 2,400 watts, and has two sets of brushes, one on each side of the machine. A switch is provided, by means of which the dynamo can be made to work either at 65 volts or at 120 volts. There is a second waggon carrying the lamps, posts, coils of wire, switchboard, &c. The equipment includes a large search light and eight arc lamps, six masts, 19ft. 6in. high, six cables wound on drum, each having a length of 160 yards, as well as coils of bare copper wire. There are two switchboards, with current regulators and differential "alarm" voltmeters, which give warning when the electromotive force varies. Among the other exhibits of this firm we may here mention their arc lamp, which burns in any position. A convincing proof of this claim is given in the Machinery Hall, where six of these lamps can be seen slowly revolving, arranged in continuation of the spokes of a wheel, which is driven round by a small electric motor.

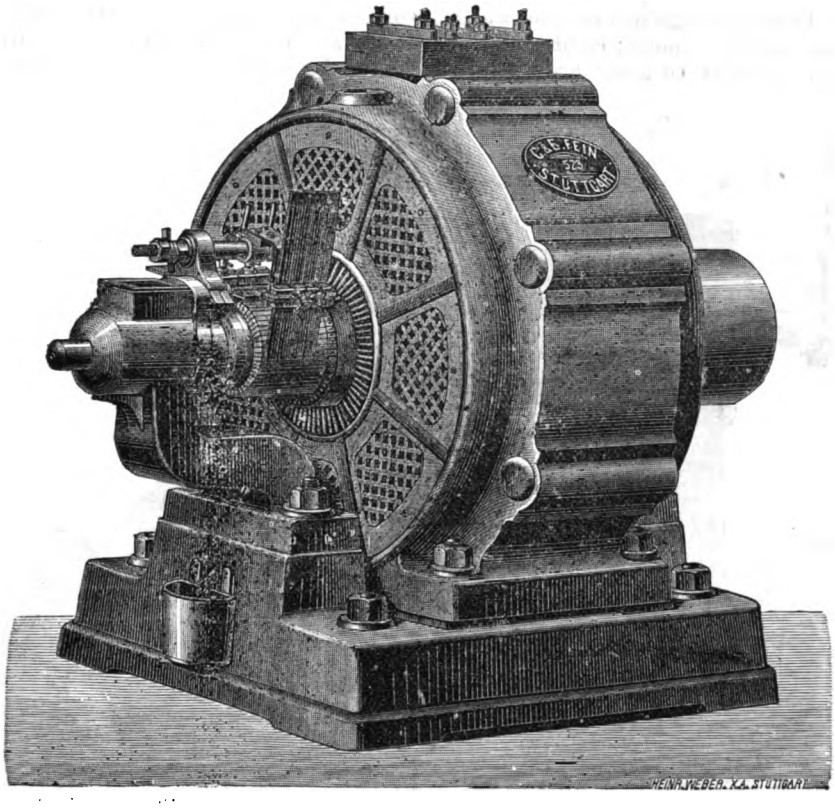

FIG. 2.—Multipolar Compound-Wound Dynamo.

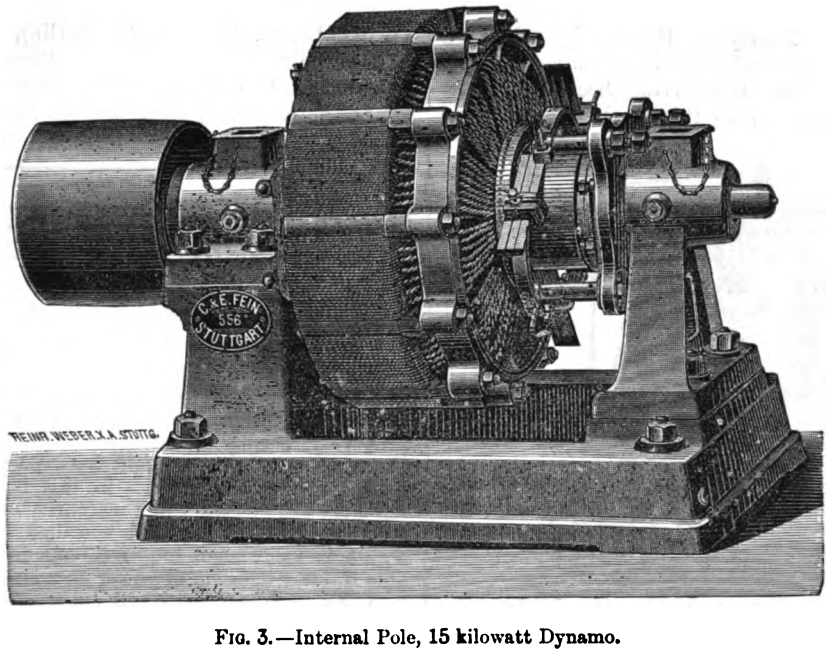

FIG. 3.—Internal Pole, 15 kilowatt Dynamo.

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The Eastern Telegraph Company has sent a very attractive exhibit to the Exhibition, comprising some of their apparatus of the newest pattern, and also the second syphon-recorder ever made. The other instruments shown are:—Signal relays (Brown), specially constructed for cable working; Saunders's lightning guards, fire-alarms, and the "Unigraph."

The work of erecting the transmission of power line is progressing very rapidly on the Frankfort-Jagstfeld section, which is being erected by the Imperial Government; eight gangs of workmen are busily engaged, whilst three gangs are working on the Wurtemburg side. Nearly all the special telegraph poles are in their places, the unusual difficulties connected with the mountainous nature of the soil having been overcome. The running of the wires commences this week. About two-thirds of a ton of oil will be necessary to fill the insulators. There is now every reason to believe that the three wires of about 120 miles each will be fixed and in working order by middle of August.

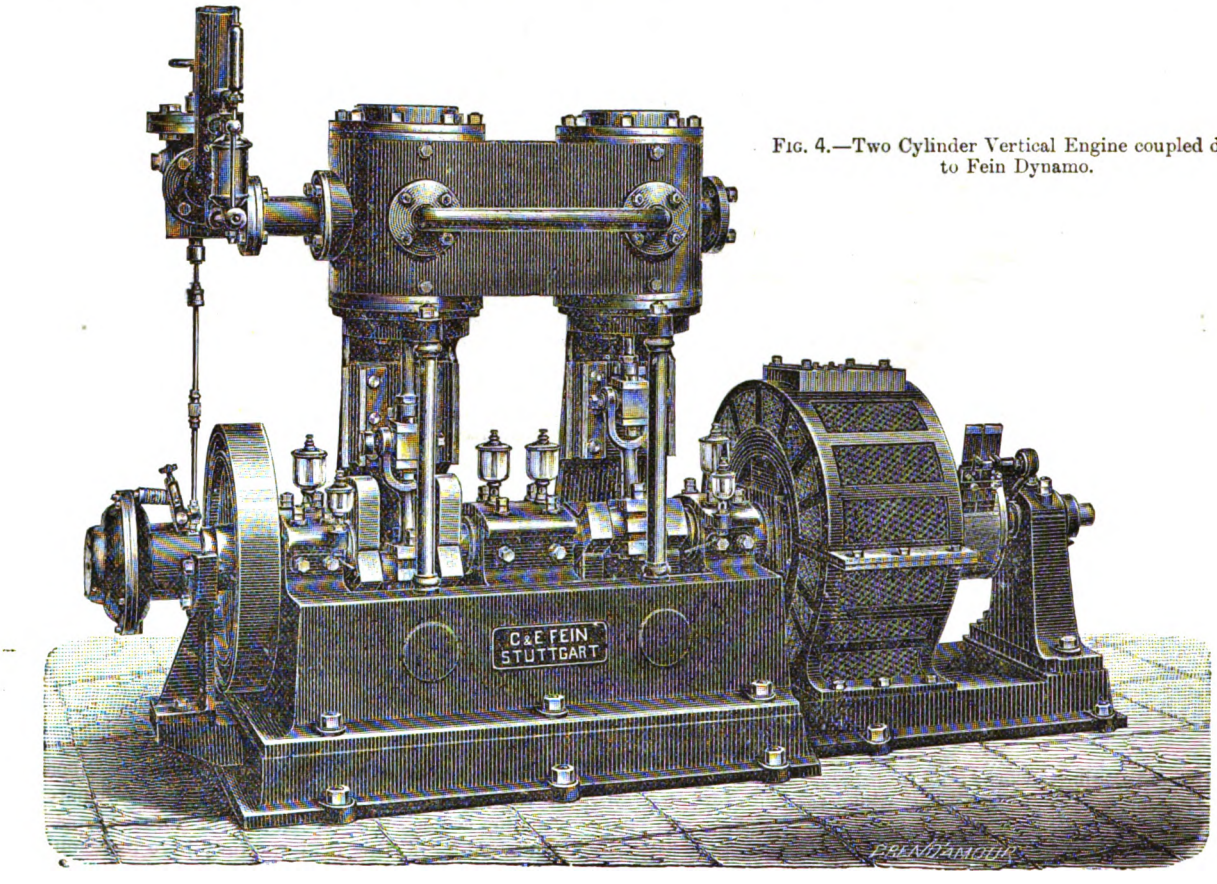

FIG. 4.—Two Cylinder Vertical Engine coupled direct to Fein Dynamo.

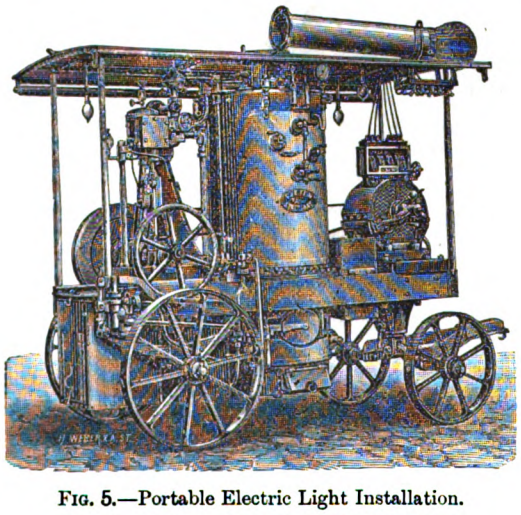

FIG. 5.—Portable Electric Light Installation.

The following are the latest lectures announced for the International Electrotechnical Congress:—"Zipernowsky, "Electric Railways for Rapid Communication between Towns;" Grawinkel, "Accumulators in Telegraphy." Among others mentioned as likely to assist at the Congress are Prof. W. E. Ayrton, Mr. Kapp. Prof. S. P. Thompson, Mr. W. H. Preece, Dr. J. Hopkinson, Mr. J. W. Swan, Mr. C. F. Brush, and Mr. R. E. Crompton; while among engineers from Germany and elsewhere are mentioned Mr. C. E. L. Brown, M. Marcel Deprez, Von Dolivo Dobrowolsky, Dr. Edelmann (of Munich,) Prof. Ferraris (of Turin), Dr. O. Fröhlich (of Berlin), Prof. Eric Gerard, Prof. Von Helmholz, Dr. Kittler (of Darmstadt), Drs. F. and W. Kohlrausch, Prof. Mascart, Herr Schuckert, Herr Carl Siemens (of St. Petersburg), Herr W. von Siemens, and Herr Uppenborn.

THE TRANSMISSION OF POWER BY ALTERNATING CURRENTS DIFFERING IN PHASE (ROTARY CURRENTS.)*

BY VON DOLIVO-DOBROWOLSKY.

The development of the industries in general, and of the electrical industries in particular, is continually increasing the importance of the transmission of power by electricity. At the time of the Münich electrical exhibition, the experiments of Marcel Deprez were very warmly welcomed, and there was an impression at the time that great things might be expected of them. For several years, however, no progress in this branch was made, the cause being the low efficiency and insecurity of the dynamos of that date, but from 1886 to 1888 the so-called English school of electrical engineers made such improvements in dynamos as to render possible the transmission of power on a large scale. During this time the Oerlikon Maschinenfabrik did great service in this direction, but continuous currents, on account of the delicacy of the commutator and the difficulty of transformation, being little suited for distribution and transmission of power over long distances, the hopes of engineers have hitherto remained unfulfilled; the construction of a continuous current machine to supply energy at 10,000 to 20,000 volts to single motors and to lamps is at present almost an impossibility, and will certainly remain so.

* Extracted from the *Elektrotechnische Zeitschrift*

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Although we do not wish to deny the many good qualities of the continuous current, we think the alternating current alone suited for the distribution of power on a large scale over long distances. But until recently there has been no practical alternating-current motor, and it is to this point that the attention of engineers and scientists has been directed. All their efforts produced no result until 1888, which must be looked upon as the year of the birth of the distribution of power by alternating currents. The discovery of Ferraris, and the investigations of Schallenberger and Tesla were published at this time, whilst many others were working on the use of alternating currents differing in phase, without, however, any practical result being reached. Tesla's motor, which attracted so much attention when it came out, does not seem to have fulfilled anticipations, as no commercial application of it has yet been made. As will be seen later, Tesla's arrangement with two quite independent currents, differing 90° in phase, possessed little advantage; its faults were avoided in the arrangements of other inventors, and motors with a larger number of alternating currents were simultaneously worked out by Bradley, Haselwander, Wenström, and the present writer.

Tesla's motor, as is well known, consists of a magnet ring carrying two sets of bobbins. These two sets are supplied by two alternating currents differing in phase by 90°. The result is a rotating magnetic field in the interior of the ring (a so-called "Ferraris," or rotating field), which accordingly acts almost exactly as if a constant magnetic field were mechanically revolved in it. On this principle extremely simple motors, without either sliding contacts or brushes, can be built. As a matter of fact, mistakes have often been made recently with regard to the Tesla motor. The following consideration will show that it cannot act in a particularly satisfactory manner. Each of the two currents displaced by a quarter phase exerts a magnetising force which at any moment

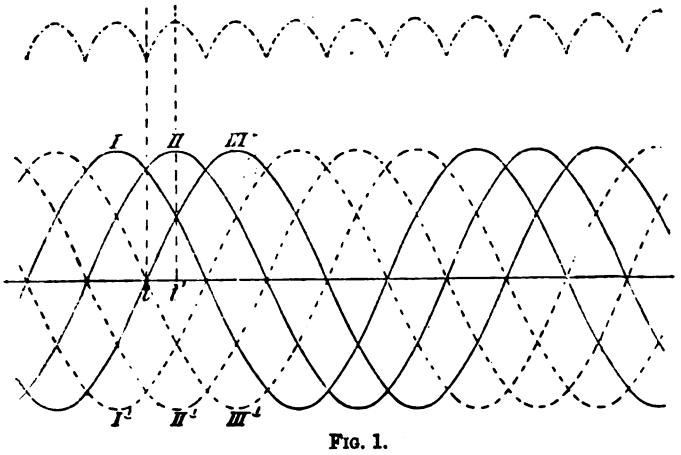

FIG. 1.

is equivalent to the product of the number of turns and the current strength at the moment. The total magnetising force exciting the motor magnet is equal to the sum of both sets of ampere turns, and is consequently also a function of the sum of the two currents. Now, in practice, this sum is never constant. It is true that in Ferrairs's arrangement the resultant force of the two sets of coils at right angles to one another on a mathematical magnetic pole must be considered constant, but this cannot be applied to material motors where the ordinary rules of electro-magnets come into force. The currents, being displaced by 90°, their sum varies between the limits i and $2\,i$ sin 45°, i being the maximum value of each current. When either current has this maximum value, the other is zero, and their sum is consequently equal to i. When the two currents are equal, as at the time t, each is equal to i sin 45°, and their sum is therefore 1·4 i. The total number of ampere turns, to which the excitation of the motor is due, therefore varies as much as 40 per cent. of its least value, so that the magnetic field of Tesla's motor is not merely rotating, but also pulsating to a very considerable extent. The action of the motor is accordingly far from being so simple as it at first sight appears. It is possible, with the help of Elihu Thomson's alternating motor, to consider the two properties of the field separately. The motor consists of a magnetic field due to an alternating current, and an armature, of which the windings form closed circuits. Like all synchronous alternating current motors, it must be brought up carefully to the proper number of revolutions per minute before the alternating current takes up the work. If overloaded, it comes to a sudden standstill, for the pulsations of the field only serve to turn the armature when it is going at a particular speed. If this is not reached they not only check, but absolutely stop rotation, because the currents induced in the closed circuit armature do not correspond properly in time and direction to the field, so that it is very difficult to start such an armature in an alternating field. Now, a Tesla motor, or, in general, a two-phase motor, as we have seen above, has a magnetic field which pulsates 40 per cent. in intensity, and it must, therefore, to a partial extent, possess the same properties as Thomson's motor: whenever Tesla's closed-circuit armature is not moving synchronously, the torque is only equivalent to the difference between the effect of its rotating field and the checking due to the pulsation of the magnetism. The motor, therefore, does not run well under load, and exhibits at full speed a tendency to synchronism up to a certain limit of load, beyond which its speed and torque rapidly diminish. The usefulness of the motor is, therefore, limited, and it can only be regarded as an improvement on the perfectly synchronous motor of Thomson, by reason of its power of starting under a heavy load when the circuit is closed.

A good motor, free from the faults accompanying synchronism, can only be produced on the principle of the rotary current by reducing the intensity of the pulsations of the magnetic field. The ideal field is absolutely constant, the lines of force rotating in exactly the same way as when a continuous current magnet is rotated. This ideal is approached by increasing the number of currents, of which the phases are made to follow one another. At the same time, it is not necessary to use very many currents. A glance at Fig. 1 will show, even in the case of three currents, the sum is sufficiently constant. At the time t, the sum is equal to 2 sin 60° × i = 1·732 i, i being the maximum value of each current. And at the time t_1, the sum is 2 sin 30° × i + i = 2 i. The pulsation of the field, which this variation of the sum of the currents involves, is, with three currents, therefore, only 15 per cent. instead of 40, as in Tesla's motor. The number of alternations being relatively small, the saturation of the iron can be carried up to a high degree without impairing the efficiency, so that, for a variation of 15 per cent. in the ampere turns, the total quantity of magnetism remains practically constant.

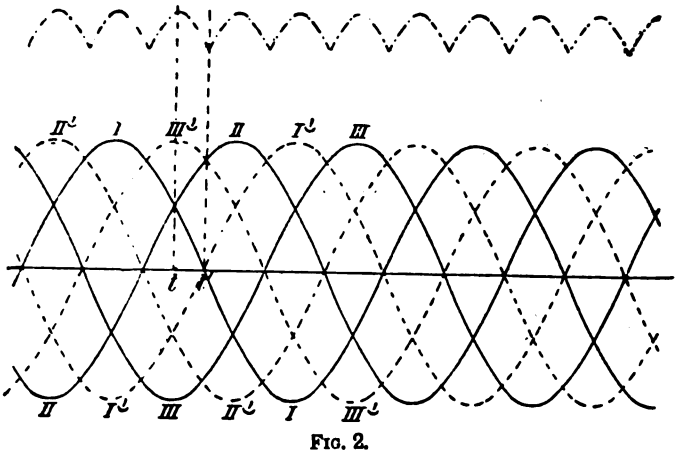

FIG. 2.

Ordinarily, the increased number of conducting wires would constitute an obstacle to the practical application of the transmission of three separate currents differing by 60° in phase. Even if it be granted that, owing to improvements in the dynamo, three currents could be conveyed by four conductors analogous to Tesla's three wires for conducting two currents, these four conductors would still be too costly. A simple arrangement allows the three currents to be conveyed by three conductors, and without using any more copper than that required for the Ferraris-Tesla device. This is made possible by supplying three currents differing by 120° instead of 60° in phase, and is effected by reversing the connections of the bobbin which supplies one current. To each of the circuits in the motor correspond at least two oppositely wound coils producing opposite poles, so that we may also add the curves obtained by reversing the signs. Fig. 1 thus becomes transformed to Fig. 2. This figure represents the three currents differing in phase by 120°, and is quite analogous to Fig. 1, in which the phase difference is 60°.

Considering Fig. 2 more closely we find that at the time t the sum of the currents I. and II. = 2 sin 30° × i, whilst III. = i, so that since sin 30° = 0·5, I. + II. = III. At the time t' again I. = 0, II. is proportional to sin 60° and III. to sin 120°, so that I. + II. = III. Generally, a similar relation holds good at any time, as may be seen from the fact that the currents are sinoidal. Each of the currents (or pressures) is equivalent and opposite to the sum of the other two, so that their algebraic sum is always equal to zero, whilst the sum of their absolute values, as above observed, varies between 2 i and 1·732 i. From the fact that the algebraic sum of the three currents or pressures at any moment is zero, it follows from Kirchhoff's laws that one current can be connected either in series with, or parallel to, the other two. This gives two methods of connecting, which are set forth diagrammatically in Figs. 3 and 4. We call the former arrangement the "open," the latter the "closed" connec-

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tion. This connection renders possible the conveyance of the three currents through three conductors, in that the current flowing in one conductor finds its way back by the other two. A similar system can also naturally be employed in the case of more than three currents being used; it was independently and simultaneously found out by Bradley, Wenström, Haselwander, and the present writer.

In the course of the careful experiments carried out by the author with the Allgemeine Elektricitäts Gesellschaft in working out the details of the system there appeared many cogent reasons for abandoning this simple arrangement. Amongst these were the small output and consequent low efficiency, the heavy cost of dynamos and motors, the difficulty of regulating and measuring the currents in the three connected circuits, and of controlling them, &c.

The following system is now being generally applied by the Allgemeine Elektricitäts Gesellschaft. The dynamos supply several perfectly independent currents, usually six, although any number may be adopted. A large number of currents enables the dynamos to be used to the best advantage in that the whole circumference of the armature can be covered with active turns which, as is well known,

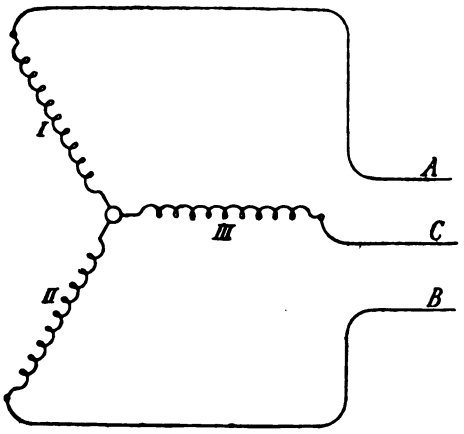

Fig. 3.

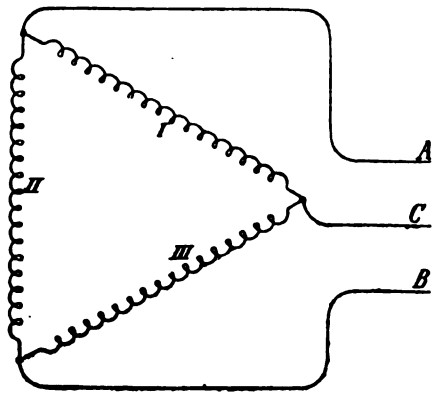

Fig. 4.

cannot be effected with ordinary alternators. An increase in the output in relation to size is also rendered possible from the fact that a multiple phase machine gives out energy continuously, whilst ordinary alternators only pulsate. The energy flowing in the conductors is also constant, since, as above pointed out, the arithmetical sum of the separate currents is practically constant, just as in the case of the continuous current. The distinct unconnected currents supplied by the machine are carried separately through switches, regulators, and measuring instruments, and then combined by suitable transformers into three connected currents differing by 120° in phase. These are conveyed wherever they are required, and finally again split up in order to be utilised. The transformer depends upon the rotation, by means of the rotary current, of a magnetic field inside a closed iron ring without poles, whilst the compound current supplied from the machine excites in the secondary coils similar current impulses following behind one another. The transformation corresponds to the action that takes place in a rotating current dynamo, except that in the transformer the field rotates about fixed coils, whilst in the dynamo the armature is mechanically rotated in a fixed field.

Since in the transformer three connected currents, differing by 120° in phase, have been produced, the idea will at once occur that the same loss will again take place as in the case of the currents directly connected. This is, however, not true. Certainly, in consequence of the connection, 15 per cent. loss in pressure takes place, and the transformation ratio is not equal to that between the number of turns, but it is only necessary to increase the number of turns in the secondary by 15 per cent. in order to fully utilise the primary currents. The efficiency of the transformer is consequently only very slightly affected. As a general rule the loss in transformation and the cost of transformers are not of great importance, since it is generally preferable to build machines for a relatively low voltage and to transform the energy to a high voltage before supplying it to the conducting wires. A dynamo for from 50 to 100 volts can be built so much more cheaply and safely that a transformer pays for itself, and the low pressure machine works so much more economically that the three or four per cent loss in the transformer is balanced. It is hardly necessary to point out that this mode of procedure is generally the only one applicable in the case of very high pressures exceeding 10,000 volts.

Fig. 5 shows a diagram of one of the numerous arrangements possible for a rotary current transformer, in which the six separate primary currents are transformed into three connected currents. The behaviour of the connected currents of the secondary winding is a reproduction of that of those in the separate primary circuits, so that the regulation of current and tension is perfectly simple. By the connection of the secondary currents we also secure the advantage that the long and, therefore, expensive conductors need only be three instead of four in number. At the second transformation at the receiving station it is preferable for the object of running large motors, just as for lamps, to resolve the combined currents again, for reasons similar to those which apply to dynamos.

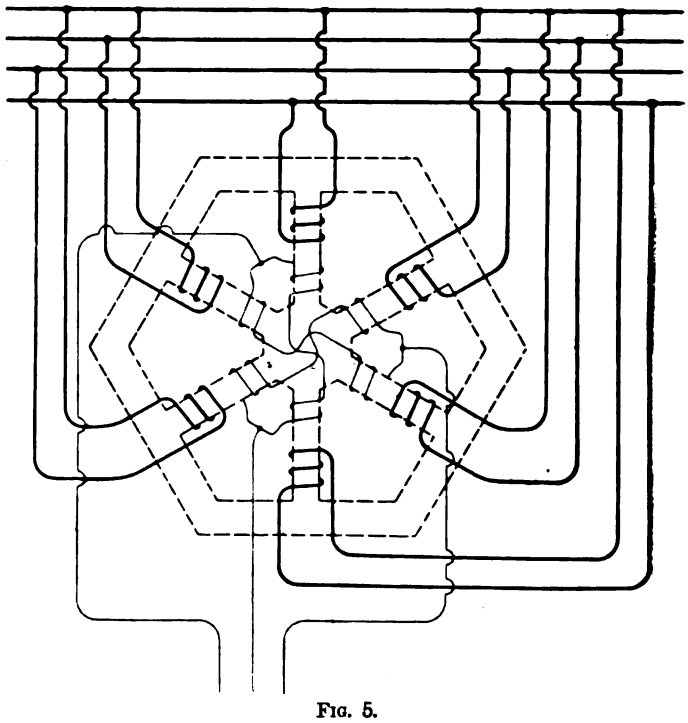

Fig. 5.

It will now be pointed out that the weight of the conductor required for equal energy is not greater for the three wires of the rotary current system than for the two wires of the ordinary system. In order to determine the conductor section for a combined rotary current, such as is used in transmitting power over a long distance, it is first of all necessary to obtain a clear idea as to the amount of energy conveyed. The solution must be obtained in the same way as in the case of an ordinary alternating current, and we therefore assume that there is no self-induction, and therefore no displacement of current with reference to electromotive force. If self-induction does exist the same modifications that occur with an alternating current also present themselves with a rotary current. Moreover, we will consider the case in which each pair of the three conductors is equally loaded since only the full normal load need be considered in determining the section of the conductor. Fig. 6 shows a conductor with a combined rotary current, the current strength being I and the pressure e. By I we mean either the maximum or the effective or the mean current strength, and not the momentary strength. The loading is effected by the three equal branches i_1, i_2, and i_3. The course of the current, as we have above proved, is always such that each current finds its way back by the other two conductors, and that the current maxima in the three conductors follow one another at intervals of 120°. I_1 is consequently split up between i_2 and i_3, I_2

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between i_1 and i_3, &c., so that there is an interval of 60° between i_1 and i_2. Hence $I = 1{\cdot}732\ i$. From this we also see that the maxima of the current I do not coincide with those of i, but that the maximum of I_1 lies midway between those of i_2 and i_3, the resultant current I being 30° removed from the separate currents i.

From the above assumption, that the apparatus does not possess self-induction, no difference in phase takes place between the electromotive force and the current to which it gives rise, so that the current i appears simultaneously with the pressure e. On the other hand, between e and I there is a phase interval of 30°, since i and I differ from one another by this amount. In other words, there exists in combined three-phase currents a phase interval of 30° between the current in one main conductor and the pressure between the other two. The total energy is equal to $3\ i\ e$, that is, to three times the energy in each branch. If, now, we put for i its value $\frac{I}{2 \sin 60°}$, we get for the total energy $3\ i\ e$ $= 3\ e \frac{I}{2 \sin 60°} = 1{\cdot}732\ I\ e$; that is to say: If the combined rotary current carries in each of the three conductors an effective current strength I with the pressure e, the energy transmitted is $1{\cdot}732\ I\ e$. If, now, we wish to convey the same amount of energy with a continuous or alternating current, the effective strength thereof must be made equal to 1·732.I. But for equal lengths of conductor and equal loss of pressure the section must be taken proportional to the current strength, whence it follows that if in the case of a rotary current of strength, I, each of the three conductors has a section equal to q, for a continuous or alternating current two conductors each of section $1{\cdot}732\ q$ are necessary. Consequently the total section can be reduced by about 13 or 14 per cent. Also from the observations given above as to the proportion between the currents in the mains and the branch conductors, it will be seen that for each ampere in the three mains carrying the combined rotary current ·866 ampere are obtained in each of the branch wires, or that a rotating current of 1 ampere is resolved into three alternating currents of ·866 ampere and of the same pressure, so that 1 ampere of a rotatory current at 100 volts represents 173·2 watts. We repeat that these relations hold good only when—(1) an equal load is thrown on to each of the three branches; (2) the load is without self-induction; and (3) the measurements are taken by separate ammeters and voltmeters, and not by a wattmeter. In the latter case the product $I\ e$ will appear smaller, since, as mentioned above, a constant difference of phase of 30deg. exists between I and e.

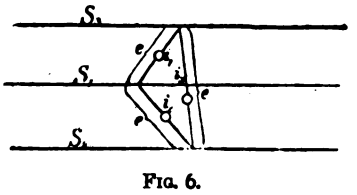

Fig. 6.

These conclusions have very little value in actual work, since, practically, the first of the three conditions never, or very seldom, holds good. Moreover, in the rotary current central station the currents are uncombined and independent, as above explained, so that the control of the loads can be very simply effected by the electrician in charge. The measurement of the consumption at the receiving station is also easy, the combined current being there resolved again into its components. The lamps are placed on two mains only, and are taken account of by simple recording apparatus, whilst the large motors are placed on separate circuits, and their consumption is measured by suitable wattmeters. For small motors supplied with the combined rotary current the measurement of one current is sufficient without any correction for the inequality in the separate circuits.

The electromotors, as above mentioned, are constructed upon the Ferraris-Tesla principle, that is to say, the different multiple phase currents produce a rotating magnetic field of nearly constant intensity, and this rotating field forces an armature with closed coils, or some similar arrangement to revolve with it. Different arrangements are adopted according to the special conditions and the size of the motors. The very small ones (up to ¼ H.P.) are constructed with a circular magnet concentric with the armature, having internal Pacinotti projections, the coils filling the space between the teeth. The armature consists of a massive iron cylinder, with numerous holes bored through it parallel to the axis; through these pass copper wires, connected at the extremities by means of two end plates, or rings, of high conductivity copper.

In another type of motor a transformer is employed fed by three wires carrying three combined high pressure rotary currents, and which supplies from its secondary double the number of currents of very low voltage, the phases of which follow close after one another. When a motor is not required to be built for specially high pressure, but it is to be worked by a low pressure current (say of 100 volts) such as is used in the mains of a town, it is advisable, especially for motors of over 1 H.P., to employ another type by which a transformation is avoided. In working out this third type of motor, the first aim was to attain a high efficiency, since in these cases the energy has to be paid for by the consumer, according to the reading of a wattmeter, and at a pretty high rate. The arrangement of this type is practically an inversion of the first. The magnet is placed inside, and rotates whilst the closed circuit armature is fixed.

We see, then, that the rotating current motors, so far as concerns their construction, are extremely simple; we will now show from some tests carried out that, as regards performance and economy they must be placed above the best direct current motors. Fig. 7 shows graphically the result of tests on a 2 H.P. motor of the type last described for 70 volts and 35 complete periods per second. The tests were carried much higher than the normal allowable load in order to determine the behaviour of the machine under excessive load and abnormal conditions. The weight of the motor was about 165 kilogrammes, and, from several trials, it appeared that a load of 2 H.P., after a long run, only heated it to a slight extent. In the interests of durability and safety this was fixed as the normal load. Since the motor can be allowed to run for a short time at double the load, it is clear that the limit taken is perfectly safe. From the weight and the curve of efficiency it appears that this load is by no means relatively low. From the curve in Fig. 7 we see that

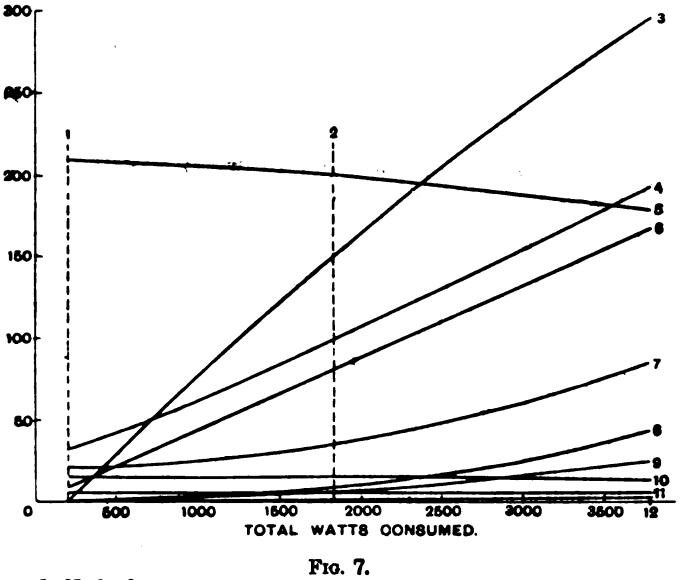

Fig. 7.

1. No load.
2. Normal continuous load corresponding to 2 effective H.P. at pulley
3. Mechanical output (watts). Scale of ordinate $\frac{1}{10}$.
4. Current strength in magnet. " " $\frac{1}{1}$
5. Number of revolutions. " $\frac{1}{10}$
6. Induced current in armature. " " $\frac{1}{10}$
7. Total losses in motor (watts). " " $\frac{1}{10}$.
8. Losses in armature copper. " " $\frac{1}{10}$.
9. Losses in magnet copper. " " $\frac{1}{10}$.
10. Air and bearing friction (watts). " " $\frac{1}{10}$.
11. Losses in iron of magnet. " " $\frac{1}{10}$.
12. Losses in iron of armature. " " $\frac{1}{10}$.

the motor is absolutely devoid of synchronism, the number of revolutions when running at no load being below that calculated from the number of alternations. Then between no load and the maximum, the number of revolutions only falls about 6 per cent., an amount which for a 2 H.P. motor is quite unimportant, and certainly below that which occurs in any direct current motor under similar circumstances. Although the speed falls off more quickly as the load is increased, it is noteworthy that at 100 per cent. overload the speed is still fairly high, and the property that alternating motors have of coming to rest when overloaded is quite done away with. From the same table we see that, starting from 205 watts, which are required when running light, the utilisable work rises nearly in proportion with the electrical energy consumed, certainly up to 3 H.P., from which point, perhaps, the proportion falls off. The output at the pulley is given in watts, in order to facilitate its comparison with the electrical values. The losses in the motor, as in every electrical machine are of three kinds. (1) Loss in the copper ($i^2 r$) in magnet and armature. (2) Magnetic losses—hysteresis and Foucault currents. (3) Mechanical losses—friction of air and bearings. All these losses in the motor are carefully

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determined separately, and plotted out in Fig. 7 as functions of the watts consumed by the motor. We see from these curves that the loss in the copper rises pretty quickly as the load is increased; it is these losses which tend to make the curve of efficiency fall off with an increased load. The loss from air and bearing friction is approximately constant, and the slight inclination of the corresponding curve towards the axis of abscissæ is due to the fall in the number of revolutions. The hysteresis and Foucault currents in the iron of the magnet are also nearly constant, falling only slightly towards the end of the curve. Hysteresis in the fixed armature, on the contrary, continually increases, because the reversals of polarity in the armature, as already explained, depend upon the "slipping" of the motor, that is, to the difference between the number of revolutions of the motor and of the lines of force. The above losses are shown both added and separately in Fig. 7. The proportion between the available output and the watts consumed gives the total efficiency of the motor, and is plotted out in Fig. 8. The output in watts at the motor pulley are taken as abscissæ, and ordinates are drawn at the points corresponding to 1, 2, 3, and 4 H.P. We see from this curve that even at 1 H.P. (half load) the efficiency reaches 75 per cent., at normal load, 2 H.P., it is over 80, and reaches its maximum 81·4 per cent at about 2·3 H.P. From the flatness of the curve it is obvious that the economical regulation of the motor is very good, and that overloading, which is unavoidable in practice, and if it lasts only a short time does not damage the motor, has very little effect on its efficiency. A comparison with direct current motors shows clearly that rotary current motors of the same size are a distinct advance in point of capacity and efficiency. It may further be pointed out that rotary current motors can start from any position with considerable force, so that no friction or other coupling is necessary.

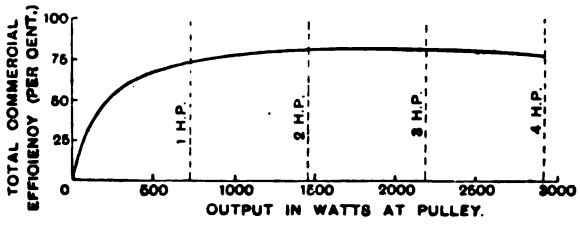

FIG. 8.

The 2 H.P. motor above referred to was tested as to its capability of starting under a load in the following way:—It was coupled direct to a direct current dynamo, the field of which was independently excited, so that a load existed as soon as motion commenced. The armature of the dynamo was connected to a circuit, the resistance of which was such that the motor at full speed was carrying more than double load. The rotary current was then suddenly thrown on, and starting was found only to take up two to three seconds. The reversal of the direction of rotation of the motor with the dynamo coupled thereto (presenting a considerable amount of inertia) was effected in about four seconds. If the load was entirely taken off, the starting of the motor by itself required no appreciable time (without resistances), and no noise was caused, it being hardly possible to hear the motor when running, even when quite close to it.

In conclusion, we will point out a very valuable property of rotary current motors, as compared with many other alternating motors. When loaded there is only a very small difference in phase between current and electromotive force, so that the proportion between the watts actually consumed in work and the apparent watts is nearly equal to unity; the conductors also do not have to be made of any larger section than corresponds to the same capacity for direct currents. From the current in the magnet (Fig. 7), which holds for one of the three circuits in the motor, and from the working pressure, we get at normal load for the apparent watts the value

$$3\ (70\ \text{volts} \times 9{\cdot}9\ \text{amp.}) = 2{,}079\ \text{watts.}$$

The actual consumption, as the curve shows, amounted to 1,830 watts, and the fraction of the apparent value is ·88. The difference in phase between current and electromotive force which, when running light, amounts to 72°, at 2 H.P. load is 28°, and at 3 H.P. 22°. Whether this proportion appears as favourable in larger motors cannot be definitely assorted, the necessary measurements not having been taken.

The chief aim of the present article has been to draw attention to the rotary current as a new means of transmitting power, and to give a general idea of the system; many points will, therefore, seem to want further explanation, and the author intends to publish a series of independent articles on the details. He also hopes that the Lauffen-Frankfort installation will afford a large number of electricians the opportunity of inspecting the system at work

ALTERNATE CURRENT MOTORS.*

BY E. HOSPITALIER.

Alternate current electric distribution, in America at least, is comparable in size and extent with continuous current distribution, and they would be much more extensive if we knew how to conveniently utilise electric energy when distributed by means of alternate currents in connection with electro-chemical operations. It would increase the number of such plants, also, if we could store the energy supplied by alternate currents, and if we could easily transform alternate current electric energy into mechanical work; for such applications the continuous current motor has remained up to the present superior to the alternate current motor. The drawbacks that I have enumerated are, however, compensated for by several advantages, viz., the simplicity of construction and cheapness of alternators, the easy production and transformation of the highest potentials (it being difficult to obtain more than 3,000 volts with continuous currents), simplicity and ease of insulation, simplicity and ease of transformation by means of inert apparatus, containing no moving parts, and having as high an efficiency as 95 per cent.

If the use of alternate currents for electro-chemical and storage purposes has scarcely yet been admitted (the partial solutions of the problem being still of an experimental character), the same cannot be said of alternate current motors. The various principles put forth, and the types based upon them, are already so numerous as to render necessary the summary classification given in the table below:—

A.—CONSTANT FIELD OR SYNCHRONOUS MOTORS.

SEPARATELY EXCITED	*Magnets.*—Magneto-Alternators.
	Electro-Magnets.—Dynamo-Alternators.
SELF-EXCITED	*"Redressed" Current.*—Zipernowsky.

B.—ALTERNATE FIELD MOTORS.

Series-Wound Dynamo	Continuous current motor, with laminated field-magnets.
Shunt-wound Dynamo	Continuous current motor, with laminated field-magnet.
Electro-dynamic Motors	Elihu Thomson meter.
Partially "Redressed" Field	Mordey.
Closed Circuit Armature	Elihu Thomson.

C.—ROTARY FIELD MOTORS.

Ordinary or Single-Circuit Alternators		Ferraris.
		Tesla.
		Shallenberger.
		Hutin and Leblanc.
Multiple Phase Alternators.	*Three wires and two currents.*	Ferraris.
		Tesla.
		Borel.
	Three wires and three currents.	Dolivo-Dobrowolsky.
		Brown.
		Haselwander.
		Bradley.
		Wenström.

An alternate-current motor does not differ essentially in principle from a continuous-current motor. The same two essential parts are always to be found; the magnetic field, or inducing magnet, and an induced system rotating with reference to the other. While, however, the magnetic field of a continuous-current motor is always constant, that of an alternate-current motor is constant, alternating, or rotary, according to circumstances.

Constant Field Motors.—This, the oldest type of motor experimented with, is based upon the principle of the reversibility of alternators. The alternate current is sent through the armature coils, which rotate in a constant magnetic field, produced by a permanent magnet or by an electro-magnet. The simplest is that formed by a Siemens double T coil revolving between the poles of a permanent magnet, or of an electro-magnet excited from an external source. In this motor, if it has been brought up to the speed corresponding to the frequency of the alternate current supplied (for example 50 revolutions per second if the frequency of the alternator is 50), it revolves in synchronism with the alternator, following all its variations of speed unless a load of more than a certain amount is suddenly applied to it. If this is done the motor is thrown out of synchronism and immediately stops. The theory of these machines was developed, in 1884, by Dr. Hopkinson. The necessity for synchronism at the start, and for an external source of electric energy for exciting the field magnet when large motors are wanted, and the necessity for running at a rigorously constant speed, have prevented these motors from receiving many commercial applications. Zipernowsky caused the two most serious of these inconveniences to disappear by rendering the motors self-exciting, the exciting current being derived from a shunt circuit containing a "redressing" commutator. A motor of this kind will start by itself when unloaded, and quickly attains its

* Paper read before the Société Française de Physique.

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normal speed, which it keeps perfectly in spite of sudden variations of load. The efficiency of these motors is very satisfactory, attaining 80 per cent. in 4-kilowatt machines. In spite of—or, more exactly, owing to—the synchronism necessary for the running of these machines, a few of them have been used for the purpose of long distance transmission of power.

Alternate Field Motors.—Any continuous current dynamo supplied with alternate currents will start and continue revolving with considerable mechanical effort. A machine of this kind is comparable to an electro-dynamometer, the torque of which always remains the same in spite of the alternations in the direction of the current. A motor of this kind, however, possesses numerous and serious defects. The rapid alternations of current develop Foucault currents in the field-magnets, greatly reducing the efficiency of the motor, unless the precaution has been taken to laminate the cores. Moreover, the high inductance of the motor reduces the current, and consequently the output, of a motor of given dimensions. For these reasons motors of this type are but little employed except where small power is wanted, as in the case of motors driving small domestic ventilating fans, taking one to two amperes at a pressure of 50 volts, such as are in actual use in America. The exciting circuits of these motors are either arranged in shunt or series. If we suppress the iron in the field-magnets and in the armature, we obtain an electro-dynamic motor of small output, the motive couple of which is at any instant proportional to the currents traversing the armature and field coils. The energy meter of Prof. Elihu Thomson comes under the heading of an electro-dynamic motor. To avoid losses by Foucault currents and hysteresis due to the rapid reversals of magnetism of the field-magnets of motors of this type, Mordey has suggested passing the alternate current through a commutator on the shaft of the motor. On starting, the commutator has no effect, but as the speed increases the current becomes more and more "redressed;" that is to say, the losses caused by reversals of magnetism are reduced and the efficiency improved.

Closed circuit motors also come under the head of motors with alternating fields. The electro-dynamic repulsion experiments of Professor Elihu Thomson have shown that a closed circuit placed in an alternating field tends to move so as to render the coefficient of mutual induction a minimum; in other words, it tends to reduce to a minimum the flux threading the coils. If we place a series of movable coils revolving round a common axis in an alternating field, and arrange the brushes so that each coil is successively short circuited at the moment when the flux threading it is a maximum, and open circuited when the flux is zero, and so on, there will be exerted on each coil a certain torque, which, owing to the multiplicity of coils, will be sensibly constant. In motors of this type there is no connection between the field and the armature. The field coils are closed on the supply wires and the motor coils are closed on themselves. Such a motor can easily be realised by means of a small Gramme or Rechniewsky two-pole machine, if we take care to give the brushes a forward lead of about 45deg. Alternate field motors are but little used, and no experiments as to their efficiency have as yet been published.

Rotary Field Motors.—Professor Ferraris, in March, 1888, was the first to make public the principle of these alternate current motors, the development of which now seems likely to cause a revolution both in long distance transmission work and in the distribution of electric energy for small motors. The following is the principle established by Ferraris:—When two alternate currents of the same period, lagging one behind the other by a quarter period, are passed through two circuits arranged at right angles, the result is a constant rotary magnetic field revolving at a constant speed, making one complete revolution per period. If now a closed magnetic circuit is placed in this rotary field, it will be the seat of induced currents, and these induced currents will tend to turn the induced circuit in the same direction as the rotary field. With the exception of the method of producing the rotary field, the rotation thus obtained is identical with that of the chemical "Avago" experiment, known under the name of "Magnetism of Rotation."

One might state with accuracy that the rotary field motor works in virtue of the Foucault currents, of which it is the seat. These Foucault currents would be zero if the circuit was stationary with regard to the field, that is to say, if the circuit revolved at the same speed as the field; and it is to fulfil this condition of relative immovability that the circuit turns within in the field, and in the same direction. In short, the circuit runs after the field.

Although of relatively recent invention, rotary field motors are already very numerous, and varied in principle and arrangement. They are distinguished amongst themselves chiefly by the mode of producing the rotary field, and by the generator which supplies current to the motor. I will now examine the ordinary alternate current motors, and the motors supplied with multiple phase currents.

There are several means of obtaining an ordinary alternate current, two alternate currents lagging a quarter phase behind each other, and capable, therefore, of producing a rotary field. Ferraris employed two circuits—one supplied with current direct from the alternator, the other connected to the secondary of a transformer, the primary of which was connected to the main leads of the alternator. Tesla employs two circuits arranged in shunt, and possessing widely different time-constants. Shallenberger employed a closed circuit armature placed obliquely with reference to the primary circuit supplied with current from the alternator, and the reactions of the primary circuit and of the armature circuit producing a rotary field. In the Hutin and Leblanc motor the rotary field is produced by two sets of coils connected in parallel, a condenser being interposed in one of the circuits. In this way the quarter phase lag necessary for the production of a rotary field is easily obtained.

The above solutions of the problem are suitable in the case of distribution to comparatively small motors. For the purpose of long distance transmission on a considerable scale, it is preferable to have recourse to special generators, no longer producing ordinary alternate currents, but several alternate currents lagging a fraction of a phase one behind the other, that is to say, "polyphasal" alternate currents. We may either employ two currents and four wires, or only three wires, using one as a common return. Devices of this kind have been brought out by Ferraris and Tesla. Being obliged to use three wires some have preferred to employ three currents of equal periodicity, but lagging one behind the other one-third of a period. By taking advantage of the employment of three currents retarded in this way, we can make the algebraical sum of the currents at any instant zero, and one of the three wires can always serve as a return to the currents traversing the other two. Such is the principle of the motors supplied with "polyphasal" currents, devised less than two years ago by Dolivo-Dobrowolsky, Haselwander, Bradley, and Wenström. A 300 H.P. transmission of power plant of this kind, due to Brown of Oerlikon, is now in process of erection between Frankfort and Lauffen.

This rapid enumeration of the methods actually employed or investigated for the convenient transformation of the energy of alternate currents for mechanical purposes shows that we may consider the problem as solved. It will doubtless be the same soon as regards the utilisation of alternate currents for electro-chemical and storage purposes. Alternating currents will then assume a commercial importance superior to that of continuous currents, and we shall witness a new evolution of electric systems, while awaiting that which the employment of alternating currents of high frequency will some day give rise to.

THE ELECTRIC TRANSMISSION OF POWER.*

BY GISBERT KAPP.

LECTURE II.—*Fundamental Principles.*

(Continued from page 366.)

What we generally desire to get in practice is a constant speed of the motor, whatever may be the mechanical power taken out of it at any moment. This condition is the same as that required from a good steam engine or other well-governed prime mover. The construction of the motor to comply with this requirement depends, of course, on the condition of supply. We can imagine a large variety of cases; but, from a practical point of view, I need only consider two, namely, supply at constant pressure such as we get, or ought to get, from mains connected with a central electric light station, and supply of current at constant or variable pressure from a generator erected specially for the purpose, the regulation of current and pressure being automatic. The latter case is that more particularly met with in long distance transmission of large powers, the former is a case referring rather to the distribution of small parcels of power over short distances from a central station. I will take this first.

We have, then, these supply conditions—pressure at the terminals of the motor constant, current variable according to the call for power. Let (in the diagram Fig. 4) the curve F represent the characteristic of magnetisation of an electromotor, that is, a curve obtained by plotting ampere-turns of exciting power on the horizontal and total field strength (denoted in the formulæ by F or Z) on the vertical. If the motor is series-wound, you see that the larger the current the stronger will be its field, and by referring to the E.M.F. formula you will find that if the speed is to remain constant the counter E.M.F. must increase in the same ratio as the field strength increases. But the counter E.M.F. must, under all circumstances, be smaller than the supply E.M.F., by just the amount required to overcome the resistance of the circuit through the motor, and this difference is, of course, proportional to the current. To satisfy the supply condition the counter E.M.F. of the motor ought to slightly decrease as the load, and with it the current, increases, then the speed will keep constant. But this is exactly

* Cantor Lectures delivered before the Society of Arts, February, 1891

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the opposite of what the motor requires. Say the machine is running at a certain speed, and giving out a certain amount of mechanical power. Now increase the load. The immediate consequence will be that the speed is slightly decreased, the counter E.M.F. is slightly decreased, and the current is increased. This will immediately strengthen the field, and thus raise the counter E.M.F. again; this will check the current, produce a further drop in speed, and so the reaction will go on until a new stable condition of working is reached at a larger current and lower speed. If we take the load off the same reaction takes place, only in the opposite sense, and the speed may become dangerously high. What I have here described happens, of course, only if the machine is worked on the rising part of the E.M.F. characteristic E, the part which we would naturally select for economical working. If we over-excite the field magnets, that is, if we employ a great deal more field wire than necessary, then we can work the machine on the drooping part of the characteristic shown by a dotted line in the diagram, and obtain approximately constant speed between certain limits, but the machine will still be liable to race as soon as we throw the load off completely. We thus find that a series-wound motor is certainly not suitable for our purpose.

Let us now inquire whether we shall be any better off with a shunt-wound motor. The field excitation in such a machine does not depend on the current flowing through the armature as in a series machine, but it is simply the result of the terminal pressure; in other words, whatever current may be required by the armature for giving power, can be and is, in fact, supplied by the source of current, without in any way affecting the field excitation. If the terminal pressure varies, the excitation and the field strength must also vary, but a variation in the working current will not directly influence the field strength. It will, however, indirectly influence it by reason of a subsidiary effect technically termed "armature reaction," and this I shall touch upon shortly. For the present we neglect it, and assume that the curve F correctly represents

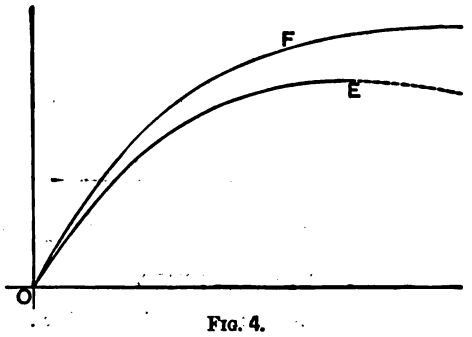

FIG. 4.

the field strength as a function of the terminal pressure. In machines having wrought-iron magnets the first part of this curve is almost a straight line, and in this region the field strength is consequently very nearly in direct proportion to the terminal E.M.F. To work the motor at this part of its curve all we have to do is to supply it with current at a pressure sensibly lower than that for which it is designed. In good machines the resistance of the armature is very low, so that only a few per cent. of the voltage supplied is lost in resistance, even when the maximum current flows through the armature. If, therefore, we work the motor considerably under its power, the armature loss will be almost negligible, that is to say, the counter E.M.F. will be very nearly equal to the supply E.M.F. Now, if you look at the formula for E.M.F., you find that on the left you have a value very nearly equal to the supply E.M.F., and on the right you have a constant multiplied with the product—field strength and speed. But the field strength under our special conditions of working is proportional to the supply E.M.F., and as you thus have the supply E.M.F. on both sides of the equation, it cancels out, and you find that the speed, multiplied by a constant, is equal to unity. This, of course, holds good for any supply E.M.F. within the straight part of the curve; and we find, therefore, that the speed has a definite value which is independent of the supply E.M.F. We have here arrived at a very remarkable result. It is this, that if you work a shunt-motor underloaded and at a lower pressure than it is designed for, you may vary this pressure within certain limits without either altering the speed or the power given out.

As, however, the motor must be large in proportion to its work, the practical use of this remarkable property of shunt-motors is limited. What users of these machines want to do is not to get little power out of them, but to get as much power as possible, and, in many cases, more than was intended by the designer. Let us, then, see how we stand in the matter of speed and power regulation when we work the machine throughout the whole range of output for which it is designed. First, as to speed. Let us assume that the machine is working at a certain speed giving off a definite amount of power, and suppose we wish to increase the speed. How shall we do it? The E.M.F. formula tells us. You see that field strength and speed occur on the same side of the equation. This means that the one can only be increased at the expense of the other. If we want the machine to run faster we must weaken its field, if we want it to run slower we must strengthen it. The variation of field strength is most conveniently brought about by a variable resistance in the magnet circuit. I have such a resistance in the shunt circuit of the machine before you, and can show you, by an experiment, this method of regulating the speed.

In this experiment we have altered both the speed and power, because, by running faster, we have obtained more current from the second machine and a brighter light in the lamp. Let us now see whether it is possible to keep the speed constant, and yet vary the power. Bearing in mind that the dynamo is a reversible machine, and drawing a parallel between a shunt-dynamo and a shunt-motor, we conclude that there should be no difficulty in doing this. The fact that a shunt-motor is an almost self-regulating machine has been first pointed out by Mr. Mordey in an article which appeared in January, 1886, in the *Philosophical Magazine*. Mr. Mordey's reasoning was somewhat as follows:—We know that a shunt-dynamo will, if driven at a constant speed, give an almost constant terminal pressure, no matter how the current may vary. Consequently, a shunt-motor, if supplied with current at constant pressure, will run at an almost constant speed, no matter how the load may vary. On testing his theoretical deduction by actual experiment, Mr. Mordey was able to completely verify it. In one set of experiments the supply current was kept at 140 volts, and the load on the motor was varied from 1·8 to 16·3 H.P., yet the speed only varied by 3 per cent.; and a similar result was obtained with the same machine at a supply pressure of 100 volts. Mr. Mordey stated in his Paper that the magnetic distortion of the field was *nil*, or, as we might also term it, that the armature reaction was negligible. It is, however, easy

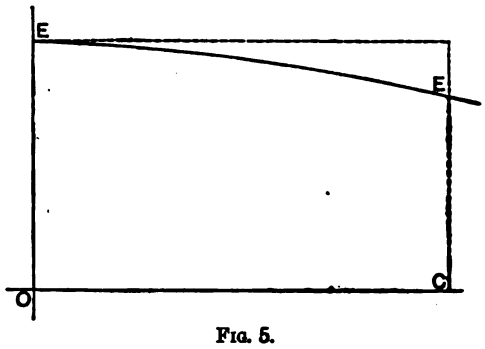

FIG. 5.

to see that, even if the armature reaction is sensible, we can yet obtain very fair regulation, provided we take care to have in the armature circuit such a resistance that the voltage loss due to the resistance is about equal to that due to armature reaction.

To explain this I must first say a few words about armature reaction, a phenomenon which may, perhaps, not be familiar to all of you. The current flowing through the armature transforms it into an electro-magnet, which, to a certain extent, opposes the flow of magnetic lines emanating from the field magnets. This is the case both in dynamos and motors, though not quite to the same extent. The larger the current the larger is the opposition which the armature offers to the field magnets; and it is the field strength which remains, after making allowance for this opposing magnetic force, which is productive of electromotive force. To calculate correctly the counter E.M.F. of a shunt-motor, we must, therefore, not assume the field strength in our E.M.F. equation to be constant, as I have done hitherto; but we must assume that it decreases slightly as the armature current increases. Graphically, this is represented in Fig. 5, where the current flowing through the armature is measured on the horizontal O C, and the field strength is represented by the inclined full line above. If there were no armature reaction, the field strength would be given by the dotted horizontal line. If the speed is to remain constant, the counter E.M.F. must be proportional to the field strength; and, by suitably altering the scale (with which we measure the ordinates in the diagram), we can take the top line to represent counter E.M.F. I have accordingly marked it E E.

The vertical distance, O E, represents now the supply E.M.F.; and, when the motor is running light, this is, of course, equal to the counter E.M.F. Now, let a load be thrown on, causing a considerable increase of current. The counter E.M.F. need now not be quite so large as before, since part of the supply E.M.F. has been already absorbed by the resistance of the armature circuit, and the counter E.M.F. need only balance the remainder. We find, thus, that the supply condition of constant voltage requires the counter E.M.F. to become lower, as the power demanded from the

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motor increases. At the same time, the working condition of constant speed can only be attained by a lowering of the counter E.M.F. as the current increases; and it is, therefore, perfectly obvious that, if the lowering of the counter E.M.F., as determined by either condition, is the same, we must have constant speed at variable power—that is, a self-regulating motor. Generally, the line E E in the diagram representing counter E.M.F. is not quite straight, but slightly curved, presenting the concave side to the axis of abscissæ; whilst the line representing resistance loss through armature is, of course, quite straight. If we so design the machine as to get exactly the same speed when running quite light and fully loaded, the speed will be slightly less at half-load, but the difference can only be very small. I am able to show you this property of the shunt-motor to be almost perfectly self-regulating, by means of the apparatus here before you.

Thus you see that the shunt-motor is an excellent machine for keeping the speed constant when worked on a constant-pressure circuit. The only drawback to its employment is, that the resistance must be inserted into the armature circuit at starting; but this may be done automatically, by placing the resistance permanently in circuit, and causing it to be short circuited by means of a centrifugal regulator fixed to the armature shaft, and so arranged that when the speed has attained a certain value the balls fly out and close a switch. Such an automatic device is also of value in case the motor should be overloaded. If this should happen the speed will drop, and the resistance will be automatically re-inserted, keeping the current within safe limits. By these means a customer of an electric light company is prevented from taking from the mains more current than he has contracted for.

Before leaving the subject of speed regulation on constant pressure circuits, I must briefly allude to a system in use on electric tramways. Motors for tram-cars are not required to run at a constant speed, but they are required to have a wide range of torque.

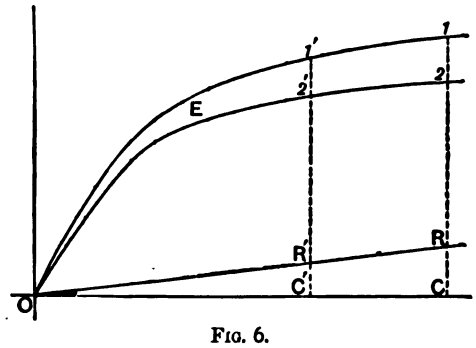

Fig. 6.

At starting, or when running uphill, the speed may be low, but the static effort must be great. These motors are, therefore, generally series-wound, and provision is made by means of a compound switch for inserting a larger or smaller number of field magnet coils, so as to vary the field strength according to requirements. The arrangement of the motors under the floor of the car is shown in the diagrams on the wall, which represent respectively the cars of Mr. Reckenzaun, the Electrical Engineering Company, and the General Electric Power and Traction Company, but time will not permit of my going into the details of the various designs.

When current is supplied to the motor not from a general system of mains, but from a special generator, serving no other purpose, the regulation of speed and power can be effected equally well by series, compound, or shunt machines. As regards the latter, I need not go into details, as this case is really included in the case of supply at constant pressure, which I have already fully treated. After what I have said about this case, you will also readily see that compound wound motors with the main coils demagnetising are equivalent to shunt-motors with large armature reaction, and that, in fact, a shunt-motor with very small armature reaction, such, for instance, as a multipolar machine, may be made self-regulating by the addition of demagnetising main coils on the field magnets. I shall later on give you details of a large transmission plant carried out on these lines, and need, therefore, not go further into the subject now. There remains, then, only the plain series motor to be considered.

In this case both the generating and the receiving dynamo are series-wound, and it is easy to see that by suitably designing these machines we can bring it about that the motor will run at a constant speed under varying loads if the generator is kept running at a constant speed at all times. Let the two curves in Fig. 6 represent the E M.F. characteristics of the two machines, the upper curve referring to the generator and the lower to the motor. These curves give the useful E.M.F. after deducting armature reaction, and refer, of course, to constant speed in each case. The current flowing through the circuit is that which we obtain by dividing the difference between the ordinates of the two curves by the total resistance. The resistance is, of course, a constant, and the curve representing current and difference of E.M.F. is, therefore, a straight line, O R in the diagram. The vertical length, C R, gives the voltage loss with a current, O C, due to resistance, and this must be equal to the voltage difference, 1, 2, between the curves. This determines, therefore, the speed of the motor for that particular current. Suppose the lower curve is the E.M.F. characteristic for that particular speed. Now, let us throw some of the load off, then the current will assume a smaller value, say O C'. The voltage loss is now C' R', and the voltage difference 1' 2'. If the E.M.F. characteristic fits this new working condition, then 1' 2' must be equal to C' R', and the speed will remain the same as before. We thus find that if we so design the machines that the difference between their E.M.F. characteristics at any working point is equal to the voltage loss by resistance, we obtain a perfectly self-regulating system of power transmission. Most of the transmissions now at work have been designed by taking advantage of this very valuable quality of series machines, but I must state at once that, in actual practice, the case is not quite so simple as I have here represented it. One of the difficulties met with is that we cannot always get the two characteristics to fit each other exactly over the whole range of output; another difficulty arises from there being generally a slight difference between the ascending and descending characteristices; but the most serious obstacle to quick and perfect regulation is the self-induction of the field magnets, especially if the machines are large. The self-induction prevents the rapid response of one machine to the other which is required to make the regulation absolutely perfect. A sudden change of load cannot be followed immediately by a corresponding change in the power supplied to the motor, as time is required by the magnets to settle down into the new working condition; and during the transitory period, which may last many seconds, there is a surging of power to and fro which creates fluctuation of speed. To mitigate this evil, Herr Dobrovolsky, of the Berlin Electric Company, has devised a plan by which a kind of electrical damper is applied to the generator in the shape of a non-inductive high resistance placed across the terminals of the magnet coils as a shunt, and left there permanently. Any abnormal wave of E.M.F. which might otherwise disturb the working of the motor or endanger the insulation of either machine spends itself in heating this resistance, and the disturbance quickly subsides.

The Line.

I pass now to the consideration of the line, a subject of great importance, especially in long distance transmission, since in these cases the cost of the line forms a very large item in the total cost of plant. You are all familiar with Sir William Thomson's law for greatest economy in conductors. Briefly, the reasoning on which this law has been developed is as follows:—The annual cost of power delivered is made up of two items. First, the cost of the power only, and, secondly, the interest on the capital outlay. The cost of power includes that amount which is wasted in heating the conductor. If I, therefore, wish to work with the greatest economy, the sum of annual interest on the capital outlay and cost of power wasted must be a minimum; and this condition is attained when the two are equal. Profs. Ayrton and Perry were the first to question the practical applicability of this law. In a Paper read by them before the Institution of Electrical Engineers, in March, 1888, they showed that, under certain conditions, better economy can be obtained by departing from, instead of following, Sir William Thomson's law. I do not propose to give you quotations from their Paper, which is highly mathematical, but I will endeavour to put the subject before you in a different way, requiring only very little mathematical treatment.

First of all, let us see, in a general way, what Sir William Thomson's law really means. It supposes that the annual electrical horse-power has a definite value at any place reached by the conductor. This is generally assumed for the distributing system as carried out from central stations. Whether a customer lives 100 yards or 500 yards from a central station, the company charges him the same for the current. But the assumption is not, strictly speaking, correct. To see this, let us suppose that the cost to the company of putting an annual horse-power into their mains is £20, and they get £30 for every annual horse-power taken by the customer. Now, if I lose 1 H.P., shall I be right in writing off this loss at £20? Clearly not; for if I had not lost this particular horse-power, I might have sold it for £30. But there is another way of looking at this. You might say that the £10 difference between the cost and selling price of power represents profit and interest of plant and mains, and that, therefore, the lost power should be debited at net cost. To this I reply, that my object is not to put power into the mains, but to take power out, or, rather, enable my customers to take power out, for which they will pay me; and so we might keep arguing the question, without ever coming to a definite understanding. Now, if we cannot settle such a simple problem by common-sense reasoning, there must be something wrong in our premises; and in this case, it is not difficult to see where the hitch is. It is in the

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assumption that the power has a constant value. In reality, this is never the case. If it were the case—that is to say, if one horse-power had the same value at the motor end as it has at the generator end of the line—it would be perfectly useless to establish a transmission plant; it would be like carrying coals from Cardiff to Newcastle. It is only because the power has a great value at the motor end of the line, and a small value at the generator end, that it will pay us to lay out capital in plant, and incur the risk of working it.

Most Economical Current for Electric Power Transmission.

D ..... Distance in miles.
a ..... Section of conductor in square inches.
E ..... Terminal volts at generator.
e ..... Terminal volts at motor.
$H P_g$ ..... B.H.P. required to drive generator.
$H P_m$ ..... B.H.P. obtained from motor.
c ..... Current in amperes.
Efficiency of generator 90 per cent.; efficiency of motor 90 per cent.
g ..... Cost in £ per electrical H.P. output of generator.
m ..... Cost in £ per B.H.P. output of motor, including regulating gear.
$G = 9 g H P g$... Cost in £ of generator.
$M = m H P_m$ ... Cost in £ of motor and regulating gear.
$t = 18{\cdot}2 D a$ ..... Weight in tons of copper in line.
K .. .. Cost in £ per ton of copper, including labour in erection.
s ..... Cost in £ of supports of line per mile run.
p ..... Cost in £ of one annual B.H.P. absorbed by generator.
q ..... Per-centage for interest and depreciation on the whole plant.

$$\text{Capital outlay} = g\,E\,c/746 + m\,H\,P_m + D\,s + \frac{1{\cdot}6\,K\,D^2\,c^2}{E\,c - 830\,H\,P_m} = A.$$

$$\text{Annual cost per B.H.P. delivered} = q\,A/H\,P_m + p\,H\,P_g/H\,P_m.$$

$$\text{Put } B = E\,p/670 + q\,E\,g/746.$$

$\gamma = 830\,H\,P_m/E$, the current which would be required if the line had no resistance,

and $\beta = \gamma^2 \dfrac{E\,B}{1{\cdot}6\,q\,K\,D^2 + E\,B}$; then the most economical current at the given voltage E is

$$c = \gamma\left(1 + \sqrt{1 - \frac{\beta}{\gamma^2}}\right)$$

$$c = \gamma\left(1 + \sqrt{\frac{1{\cdot}6\,q\,K\,D^2}{1{\cdot}6\,q\,K\,D^2 + B\,E}}\right).$$

For very long distances the term under the square root approaches unity, and the most economical current the value 2γ; from which it follows that under no circumstances will it be economical to lose more than half the total power in the line.

The correct way of treating this problem is, therefore, to take into account the cost of the power, both at the generating and at the receiving station. We must, further, take into account not only the interest and depreciation of the line, but also the interest and depreciation of the machinery at either end; and, in estimating these items, we must know at what voltage the plant is to work, and what total power is required; for the prime cost per horse-power depends very materially on the total power and voltage. To make this clear: if I want to reduce the capital outlay on the line, I must work at high voltage, and with a large energy loss. This means that I must put down a larger generator than would otherwise be required, and, moreover, one that gives a high-pressure current. It is thus quite possible that what I save in the line I shall have to expend at the generating station, to say nothing of the increased charge for waste power, and the greater liability to have a breakdown, owing to high voltage.

You see this problem is a very complicated one; and Thomson's law, which says nothing about voltage or cost of machines, will not fit it. It is, however, possible to amend this law, so as to obtain at least an approximate solution. The premises on which the formula has been deduced are as follows:—

Conditions given.—Annual value of brake horse-power at generating station; voltage at generator terminals; brake horse-power required at motor end; distance of transmission; cost per horse-power of machines and regulating appliances at the given output, and voltage; cost of conductor, per ton of copper erected, interest, and depreciation of whole plant.

Data required.—Working current, brake horse-power at generating station, mechanical efficiency, voltage at motor, total capital outlay per brake horse-power delivered, and cost of annual brake horse-power.

The efficiency of each machine is assumed to be 90 per cent. The formula gives only the current, but the other data can be found by very simple calculations, which need no explanation. The cost of supports for the line per mile, whether overhead or underground, can be taken as constant, that is, not depending on the exact current within the limits, which can easily be foreseen in each case; and it therefore does not enter into the formula for the current. Interest and depreciation I have taken the same for all parts of the plant, so as to avoid too great a complication of the formula. If you now work out by the aid of the current formula the same transmission problem for different voltages, you will find that there is one particular voltage for which the annual cost of the brake horse-power delivered at the motor end of the line is a minimum; and, provided this voltage is within reasonable limits, it ought to be adopted. When making such calculations, you will find that the greater the cost of power at the generating station, the higher is the most economical voltage, this voltage also, of course, increasing with the distance.

Each case must be worked out with due regard to local conditions, and nothing in the shape of cut and dried rules or figures can make this work superfluous. On the other hand, it is very desirable to collect information as to the cost of works which have actually been carried out, and by the liberality of Mr. Brown, the engineer to the Oerlikon Works, Switzerland, I am able to place before you some figures of this kind which are contained in the following table. The figures give the whole capital outlay for the electrical parts of some of the power transmissions erected by this firm:—

Cost of Transmission of Power Plant.

Distance in miles.	H.P. Delivered.	Speed of Machines.	Cost in £.			Total Cost.*	Cost per H.P
			Gen.	Mot.	Line.		
1·870	85	450	640	560	440	£1,880	£22·2
·280	195	500	760	680	132	1,800	9·7
·280	51	600	320	280	60	720	14·1
·375	90	550	520	480	80	1,240	13·8
·560	71	600	440	400	60	1,040	14·6
·280	40	700	260	240	20	640	16
·375	75	600	480	440	68	1,120	15
·500	87	500	520	480	100	1,260	14·5
1·560	150	600	760	720	330	2,050	13·7
·220	93	450	440	420	232	1,270	13·7
6·250	11	900	132	110	480	960	87
2·200	51	600	360	320	300	1,140	22·4
·187	60	900	240	220	18	600	10
5·000	41	750	240	200	344	1,020	24·8
3·750	220	600	1,040	960	640	2,960	13·5
·002	15	600	112	104	8	252	16·8
·250	19	700	160	160	20	390	20·5

* This includes regulating apparatus, instruments, posts, insulators, lightning arresters, erection, and supervision.

LEGAL INTELLIGENCE.

Crompton and Co. v. Phillips.

In the Court of Appeal, on Friday last week, the case of Crompton and Co. v. Phillips came before Lord Justices Lindley, Bowen, and Kay, in the form of an appeal by the defendants from the judgment entered in the Court below in favour of the plaintiffs.

Mr. Finlay, Q.C., and Mr. Wallace appeared for the defendant in support of the appeal, while Mr. Moulton, Q.C., and Mr. Graham opposed it on behalf of the plaintiffs.

Mr. FINLAY, in support of the appeal, said he now asked that judgment should be entered for the defendant, or a new trial granted, on the ground that the verdict of the jury was against the weight of evidence. The action was brought by Messrs. Crompton and Co., the well-known electrical engineers, against Mr. Phillips, manufacturer of wires used for electrical purposes, to recover damages for an alleged failure to perform a contract for the supply of certain insulated wire. The defendant manufactured three qualities of insulated wire, which were known as B, C, and D qualities, B being the lowest quality, C the medium, and D the best. On June 4, 1889, the plaintiffs wrote to the defendant, stating that they required a certain quantity of insulated wire for the purpose of supplying the borough of Chelmsford with the electric light, and asking him to quote special terms for B and C qualities. The defendant replied to that letter on the following day, giving the quotations asked for, and the plaintiffs eventually ordered a large quantity of C quality. Having put up nearly 60,000 yards of this wire in the open air at Chelmsford, the plaintiffs complained of the quality of the wire supplied. They removed some of the wire, but left standing about 35,000 yards. The case was tried before Mr. Justice Day and a special jury, with the result that the jury found a verdict for the plaintiffs, and added that the plaintiffs had been guilty of contributory negligence in not examining the wire, which was an exceptionally bad article. Mr. Justice Day entered judgment for the plaintiffs, leaving the question of damages to be decided by two experts. The defendant's position at the trial was this, that the wire in question was perfectly good so long as it was used for the purpose for which it was manufactured and ought to be employed. It was perfectly suitable for use indoors, but they did not make it for use out of doors, and the whole of the loss which the plaintiffs said they had sus-

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tained was due to their using such a cheap wire out of doors. That was what the jury meant by their verdict.

The case was then adjourned.

TUESDAY, AUGUST 4TH.

Mr. WALLACE continued the arguments in support of the appeal. He submitted that C wire ought to be tested in the dry.

Mr. MOULTON said Mr. Finlay had admitted that the proper way to test the wire was to put it in water.

Mr. WALLACE remarked that that was the proper test for guaranteed wire.

LORD JUSTICE KAY: Then your argument comes to this—that C wire is not to be tested at all?

Mr. WALLACE: I say it is not to be tested by putting it in water. Continuing, the learned counsel said Mr. Crompton had admitted that the use of the wire at Chelmsford was an experiment which he had made for the first time. The alleged faults in the wire were not defects, they were characteristics of the wire.

LORD JUSTICE KAY: That is going rather too far. Is it a characteristic to have a crack every five yards?

Mr. WALLACE: No. That was not the case with this wire. The plaintiffs accepted the wire, used it, and made no complaint until the Board of Trade informed them that it was not thick enough for the voltage. He submitted that the verdict of the jury was not justified by the evidence, and that it ought to be reversed.

LORD JUSTICE LINDLEY said the Court would like to hear Mr. Moulton in reference to the one point. They did not feel that the learned judge, notwithstanding his great efforts, succeeded in keeping the minds of the jurors upon the only point they had to consider, namely, whether the wire supplied was merchantable in quality. If Mr. Moulton satisfied them upon that particular point they would not trouble him further.

Mr. MOULTON maintained that the judge made the point clear to the jury, and that the jury found for the plaintiffs upon the evidence. The opinion which the jury added to their verdict meant that if the plaintiffs had examined the wire before they used it they would have rejected it at once, and thereby saved the expense of putting it up and taking it down again. That was a perfectly intelligible finding, because the plaintiffs claimed the costs to which they had been put in fixing and removing the wire.

The case was again adjourned.

WEDNESDAY, AUGUST 5TH.

Mr. MOULTON, continuing his arguments, contended that the wire supplied was not merchantable insulated wire. It was unfair to Messrs. Crompton to suggest that they had purchased a low priced article. Mr. Crompton stated, at the trial, that the wire in question was a high priced wire. Mr. Justice Day would not allow the plaintiffs to give evidence on the question of price, remarking that if they had paid a high price for a bad article that was their look out.

LORD JUSTICE LINDLEY, in delivering judgment, said that the question raised was an important one, not only to the parties but also to persons interested in electric lighting. The order for the wire was contained in three letters, from which it was obvious that plaintiffs knew defendants sold B and C qualities of wire. Mr. Justice Day, at the trial, directed the jury, from the beginning to the end, that the only question they had to consider was whether the C quality wire supplied by defendant to plaintiffs was a merchantable quality wire, telling them there was no guarantee in the letters. It was admitted that the distinctive marks of this wire were not known in the trade, but were terms used by defendant to denote a particular article. The point at issue, then, was reduced to this—did the C quality wire mean covered wire or did it mean insulated wire. If it meant covered the defendant had performed his contract, if insulated he had not. Now, it was said that the failure of the wire arose entirely from its having been applied by the plaintiffs to a purpose for which it was not intended and was unfitted. That was true, but how came it to be so applied? Plaintiffs assumed, and had a right to assume, that C wire was of merchantable quality; in other words, was insulated as distinguished from merely covered wire. The verdict had been rightly described as a curious one, and more than one interpretation had been placed on it in the arguments. What he (his Lordship) thought it meant was this: "We (the jury) are not going to give you (plaintiffs) the cost of putting up and taking down wire which you ought to have examined before erecting it." But this did not carry the case further for the defendant, and it appeared to him that, guided by the rules which ordinarily applied to these cases, it was impossible to say that this verdict was against the weight of evidence, that this Court should interfere with it. The misunderstanding which arose he attributed entirely to the ambiguity of the letters on which the contract was based. The appeal, he thought, should be dismissed.

LORD JUSTICE BOWEN said he was entirely of the same opinion.

LORD JUSTICE KAY said he was also entirely of the same opinion. The card containing samples of the three kinds of wire described C quality as being wire insulated by being covered with vulcanized india rubber. During the progress of the work at Chelmsford the plaintiffs were anxious to know what was the resistance of the insulation, and the defendant replied that the approximate resistance was 250 megohms per knot. Subsequently, when the wire was tested by being placed in water, the insulation was found to be very defective. In the case of some of the specimens the electric current escaped altogether. Agreeing with his learned brother (Lord Justice Lindley) that the question for the jury was whether the wire sold and purchased as insulated wire was, in fact, insulated wire, he was of opinion that there was evidence upon which the jury might well find that, whatever else "C" quality meant, it meant, at least, this—that the wire was insulated, and that the wire supplied to the plaintiffs was either not insulated at all, or was so very imperfectly insulated that it did not deserve the name of insulated wire. There was certainly ample evidence to justify the finding that the wire supplied was not the wire the plaintiffs contracted to buy, and, that being so, it was quite impossible for the Court to disturb the verdict.

Mr. MOULTON asked that the appeal should be dismissed, with costs.

LORD JUSTICE LINDLEY said the appeal would be dismissed, with costs.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *July* 25, 1891.

The Brush Accumulator Patent.—The protracted patent litigation between Mr. Brush and the Electrical Accumulator Company has just been terminated by the decision of Judge Coxe emphatically in favour of the former. This practically gives Mr. Brush and his assigns the monopoly of the lead accumulator in this country if they choose to assume it. From the nature of Judge Coxe's decision last year in the suit between the Julien and Brush interests the result of the present action was to be anticipated. What its effect will be it is as yet too early to state. The Julien Company, sole licensee, under the Brush patents, certainly holds the key to the situation. Apropos to this the United Electric Traction Company will resume, it is stated, the operation of its accumulator cars on the Fourth Avenue road in this city, which have been discontinued for some months.

The Edison Lamp Patent.—Everyone is waiting with interest the action of the Board of Directors of the Edison General Electric Company, in the matter of incandescent lamps. Judge Wallace has just granted a stay in the matter of the injunction ordered in the decree accompanying his opinion, and the case will go to the Circuit Court of Appeals, probably immediately after the opening of its session next October. It will probably be the first case on the docket of this tribunal. Meanwhile, the United States Electric Lighting Company has given bonds in $50,000 to cover the alleged infringement during the period that elapses before the decision is heard under the appeal. In granting the stay Judge Wallace frankly stated that there was a fair chance that his decision might be reversed in the Upper Court, and said, in substance, that the claims of the Edison patent were in such loose terms that there was little wonder that they had been infringed. In the meantime, the incandescent lamp manufacturers are awaiting further action on the part of the Edison Company. Those most interested are the small makers. It is rumoured that the Thomson-Houston Company has entered into some sort of an agreement with the Edison Company in this matter, and the rumour is strengthened by the fact that some of the Thomson-Houston officials have expressed themselves as rather satisfied than otherwise with the nature of the decision.

Forthcoming Meeting of the National Electric Light Association at Montreal.—Preparations for the semi-annual meeting of the National Electric Light Association in Montreal are rapidly progressing. The exhibits promise to be very fine, and a very large attendance is expected. Some radical changes were made in the administration of the association at its last meeting, and the healthy effect of these has already made itself very manifest.

Work in the Edison Laboratory.—At Mr. Edison's laboratory some important work is going on, but the details have thus far been successfully kept from the inquiring public. It is known that the alternating current system is nearing its finished form, in which it will be put upon the market. Apart from this, Mr. Edison's own time is largely taken up with his mining work, the applications of the magnetic separator in particular; so far he has obtained excellent results.

BOOKS, &c., RECEIVED.

"Journal of the Institution of Electrical Engineers." Vol. XX. No. 94. (London: E. and F. N. Spon.)

"Steam Boiler Construction." By Walter S. Hutton. (London: Crosby Lockwood and Son).

"Elements of Dynamic Electricity and Magnetism." By Philip Atkinson, Ph.D. (London: Crosby Lockwood and Son.)

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TRADE NOTES AND NOTICES.

[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.]

NOW READY.—"THE ELECTRICIAN" PRIMERS (38 in all, Vol. I., 20; Vol. II., 18), in two volumes. Price per volume 2s. paper covers, 2s. 6d. cloth; post free, 2s. 2d. and 2s. 9d. respectively. Single copies, 3d.; post free, 3½d. Prospectus on application to the Publisher.

ELECTRIC LIGHTING OF THE CENTRAL STATION, MANCHESTER.—The Cheshire Lines Committee have recently decided to erect an installation for the complete lighting of their central station, Manchester, and have placed the order for the whole of the plant with Messrs. Mather and Platt, of the Salford Iron Works. The plant will consist of incandescent lamps for the refreshment rooms, ticket offices and waiting rooms, and of arc lights for the platforms. The plant is to be in duplicate throughout, and will consist of compound engines, "Edison-Hopkinson" dynamos for the incandescent lighting, and "Manchester" dynamos for the arc lighting.

CHANGES OF ADDRESS.—Owing to the increase in their London business, Messrs. Walter T. Glover and Co. have removed from 10, Hatton-garden, to larger and more commodious offices at Albany Buildings, 39, Victoria-street, Westminster, where are situate the new offices of Mr. Henry Edmunds. Considerable alterations and extensions having been made in their works at Manchester, Messrs. Glover and Co. are now prepared to give prompt delivery from stock of wires and cables for electrical purposes, in vulcanised, pure india-rubber, and gutta percha insulations; silk and cotton covering, and their patent braiding; as well as armoured and lead-covered cables in all sizes, concentric cables, and their patent anti induction and other telephone cables.

———. The Electrical Accessories Company (Limited) notify that their London office has been removed from Victoria-street to 5, Macclesfield-street, Shaftesbury-avenue, W.C., where larger and more convenient premises will enable them to keep a stock of all their well-known specialities, as well as a good selection of brackets, standards, and electroliers of all styles.

DISSOLUTIONS OF PARTNERSHIP.—Anders and Elliot, electrical engineers and telephone manufacturers, 10, Bush-lane, Cannon-street, London, E.C. February 7, 1889. Debts by C. H. Elliot. ——Poland and Childs, trading as Thurkle and Co., electrical and pneumatic engineers, 22, Denmark-street, Soho, London, W. June 5, 1891. Debts by H. E. Childs.

BANKRUPTCY PROCEEDINGS.—A receiving order has been issued in the estate of Montagu James Scott, trading as Montagu J. Scott and Co., electrical engineers and contractors, 11, South Molton-street, and 134, Regent-street, London, S.W.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

June 30, 1891.

11,134. C. A. FAURE. London. Improvements in apparatus for the electrolysis of aluminium.

11,144. H. VAN HOEVENBERGH. London. Improvements in printing telegraphs.

11,145. D. H. BATES and H VAN HOEVENBERGH. London. Improvements in and connected with printing telegraph instruments.

11,149. E. GUITTON. London. A multiple filament electric incandescent lamp. (A. Collet, France).

July 1, 1891.

11,157. J. RADCLIFFE and J. E. SPAGNOLETTI. London. Improvements in transmitters and receivers for telephones.

11,181. H. A. MAVOR, W. A. COULSON, S. MAVOR, and W. B. SAYERS. Glasgow. Improvements in electric switches.

11,201. J. SACK, E. VON MALTITZ, and P. ZIESEL. London. Improvements in apparatus for telephonic communication.

11,211. M. KALLMAN and THE COMPANY ALLGEMEINE ELEKTRICITÄTS-GESELLSCHAFT. London. Improvements in interrupters for strong electric currents.

July 2, 1891.

11,225. F. J. REBMAN. London. The improvement of production of electricity by means of a dry cell battery.

11,278. E. HANCOCK and A. J. MARQUAND. London. Improvements in the production of elements for electric or secondary batteries.

July 3, 1891.

11,294. A. R. BENNETT. London. An improved system of telephonic exchange signalling.

11,301. P. R. DE F. D'HUMY. Liverpool. Improvements in or relating to driving electric current generators for lighting steamships and railway trains, and for other purposes, and in apparatus therefor.

11,313. R. BOLTON. London. Improvements in means or apparatus for utilising electrical energy in operating rock boring and other mechanism.

July 4, 1891.

11,407. F. W. CANNON. London. An improved thermo-electric meter.

July 6, 1891.

11,447. H. D. NORMAN and H. A. PAYNE. London. Improvements in electric arc lamps.

11,473. H. H. LAKE. London. Improvements in alternating current electromagnetic motors. (N. Tesla, United States).

11,476. R. J. BOTT. London. An improvement in key or switch sockets for electric lamps.

SPECIFICATIONS PUBLISHED.

1890.

9,683. ATKINSON. Electrically-driven percussive tools (Price 8d.)
10,624. SCOTT. Dynamo-electric machines. (Price 8d.)
11,817. ALDRICH. Electric light fixtures. (Price 8d.)
11,862. AYRTON and MATHER. Electrostatic measuring instruments. (Price 8d.)
12,475. TANSSIG. Electrical smelting. (Price 6d.)
12,713. DE FERRANTI. Electric mains. (Price 8d.)
12,736. BARR and STROUD. Telemeters. (Price 8d.)
12,915. JARMAN. Dynamo electric motors, &c. (Price 8d.)
13,129. SLATER. Safety fuses for electrical circuits. (Price 8d.)
13,232. WISE (Finney). Magnetic separators. (Price 11d.)
13,256. GENT and OTHERS. Coin freed electrical apparatus. (Price 8d.)
13,260. DOBROWOLSKY and MAMROTH. Distribution of electricity. (Price 8d.)
13,358. SIEMENS. Driving winches, &c., by electrical motors. (Price 6d.)
13,359. SIEMENS BROS and Co. (Limited). (Siemens and Halske). Electrically-propelled cars. (Price 8d.)
13,619. LINEFF. Electric conductors. (Price 8d.)
13,735. HOEPFNER. Electro-metallurgical operations. (Price 8d.)
14,050. SIEMENS BROS and Co. (Limited). (Siemens and Halske). Electrical cut-outs. (Price 6d.)
14,609. MILLS (Jobson). Electrically propelled vehicles. (Price 8d.)

1891.

1,599. ELLIOT. Stopping water wheels used in generating electricity (Price 8d.)
5,508. HEMMING, Electro-plating wire. (Price 6d.)
5,963. SAUNDERS and BROWN. Electric "hooter" (Price 8d.)
6,378. DEPOELE. Electric motors. (Price 8d.)
8,141. THOMPSON (Williams). Insulated electric conductors. (Price 8d.)
8,183. FITZPATRICK. (Schubardt). Electric alarm, &c. (Price 8d.)
8,540. MOORE and WARREN. Electric railways. (Price 6d.)
8,555. THOMPSON (Williams). Insulated electric conductors. (Price 8d.)
8,575. TESLA. Generating, &c., electric energy. (Price 8d.)
8,648. BAZIN. Producing electric light and cold. (Price 8d.)
8,922. PRENTISS. Electric clocks. (Price 8d.)
8,924. LAKE (Kaliske). Electric circuits. (Price 6d.)
8,932. LAKE (Eickemeyer). Electric locomotives, (Price 1s. 3d.
9,435. LAUCKERT. Electrical transformer. (Price 6d.)
9,436. WILLIAMSON. Electrical transformer. (Price 6d.)

COMPANIES' MEETINGS & REPORTS.

Anglo-American Telegraph Company (Limited).

The ordinary general half-yearly meeting of the proprietors of the Anglo-American Telegraph Company (Limited) was held at Winchester House, 50, Old Broad-street, on the 31st ult., under the presidency of the Most. Hon. The Marquis of Tweeddale.

The Secretary (Mr. T. H. Wells) read the notice calling the meeting and the minutes of the last general meeting.

The CHAIRMAN: Gentlemen, I have now to ask you to adopt the report and the accounts, which have been in your hands some days, and which, I presume, you will take as read. The traffic receipts, amounting to £136,483 for the past half-year, show a decrease of £8,432 as compared with those of the corresponding period of last year. The whole amount available for dividend is less by £14,517, and is made up as follows:—Traffic receipts, to which I have referred, £8,432 less; on account of the charter of the "Minia" £3,340 less; interest on deposit account, &c., £629 less, and the balance brought forward £1,403 less; while the balance on account of the increase of expenses is unfavourable to the extent of £713. These items make up the total of £14,517. The dividend of 12s. per cent. which we are only able to pay is not a little disappointing to us, of course, but I do not think anyone will be surprised at this result who has kept his eyes open to the state of affairs, more especially of the commercial world, during the period under review. Not only has our income been adversely affected by the stagnation of business

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following on the financial difficulties of last autumn, but in other ways our receipts have been reduced. For instance, owing to the interruption on the West Coast of South America, our traffic has been reduced to the extent of £10,000. I am happy to say that the interruption which existed so long is now removed, and our traffic in that quarter has resumed its normal condition. I only wish I could add that the depression in commercial circles had disappeared also. Still I think there is no reason to question that it will disappear in the course of time—not a very long time, I hope—and then our traffic will again recover its usual proportion. At any rate, Gentlemen, of this I am quite satisfied—that we have not suffered in any degree more than our competitors in the Atlantic. Nor, I think, can the reduced receipts be ascribed to any want of activity on our part in securing traffic. The report has told you that we have established new offices in several commercial centres. We have also provided a through wire from Paris to Brest and Havre, and have thus placed ourselves on an equality with our competitors in that country. Canvassing both at home and abroad has been pursued with great energy, and, I am glad to say, with corresponding successful results. I have the returns here which show what has been accomplished, and I observe that in one country, Belgium, our increase for the six months, compared with 1890, is about double, and in France about 25 per cent. Then at Southampton and other places the increase is very considerable. These increases are prineipally due to greater activity on the part of those who are looking after and collecting traffic for us. I daresay there are some persons who may remember the criticisms that were passed on our Company at our last meeting by one of our largest shareholders and customers. He complained that our lines were subject to interruptions in the winter which greatly interfered with his business. Well, I am happy to say that our friends of the Western Union Company have shown themselves alive to the necessity and importance of placing our communications under their control in a far more satisfactory condition. I have a letter here, the whole of which I shall not read, but I may read a few lines of it. It is a letter from General Eckert, who is the able manager of the Western Union in New York, and he says: "I have no hesitation in assuring you that even with a repetition of that experience (namely, the unparalleled bad weather of last winter), the precautions we have taken, and, I may add, without regard to cost, will prevent any appreciable delay in the business on the other side." In addition to that, your Directors have determined to take steps to connect Sydney, Cape Brèton, and Canso, Nova Scotia, by cable, and in this way we shall have direct communication by submarine cable between England and France and New York, which we have never yet had since our Company was established. I think that if Mr. Leon, the critic to whom I have referred, and whom I am glad to say is now a Member of Parliament, has the time to cast his eye over the report of our proceedings to-day, he will be glad to learn that his criticisms have borne fruit in the way I have just described. Gentlemen, the additional facilities thus given to the telegraphing public have not been provided without some increase of expenses, but our policy has been—and I trust it ever will be—to render our service as efficient as possible, not only with respect to speed (I doubt if we could do better in that respect than we are now doing) but with regard to freedom from interruptions and, above all, with respect to accuracy. I may mention that particular attention has, during the past year, been devoted to this matter, and I am pleased to say with very good results. Our cables are in good order generally, the only exception, indeed, being a short line known as the North Placentia cable, which has given us a great deal of trouble, and which will require some additional cable in order to make it as efficient as it should be, but I hope that by the time I address you again, this defect will be entirely removed. The accounts call for no particular comment, because I have already referred to the increased expenditure under the heads of B and C, and have explained that it was almost exclusively due to the improved facilities I have described. The renewal fund has reached the handsome figure of £990,000 in round figures, and it is, at current prices, worth about £29,000 more. It may interest you to know that during the last four and a-half years, we have charged the renewal fund with repairs and renewals about £120,000, being at the rate of about £27,000 a year. Our income from the renewal fund is about £32,000, so that for these years past we have been adding to the renewal fund at the rate of £5,000 a year. I do not think there is any other point upon which I need speak at any great length except with respect to the interesting question of the French cable, the Pouyer-Quertier cable, and as there may be some shareholders present who are not acquainted with the history of that matter I have drawn up a very brief memorandum showing exactly what has taken place from the beginning. If you will allow me to read it, it will not take more than a moment or two, and it will show you what the position of the case is at present. On December 30, 1886, M. Granet, Minister of Posts and Telegraphs, wrote to the French Company to the effect that by amalgamating its interests with foreign companies it had departed from the terms of the concession, and should take steps for observing the same. The next day the French Company denounced the agreements on the ground that the Minister's letter was an order obliging them to do so; whereupon proceedings were commenced by us in the Tribunal of Commerce. On January 9, 1888, that Court had decided that the French Company must resume the performance of the agreements under a penalty of 5,000 francs per day for every day's delay until the expiration of one month, and adjudged a considerable sum to be paid to this Company by way of damages already incurred. The French Company appealed from this judgment, and the Court of Appeal, on April 24, 1888, suspended judgment until competent authority had declared whether the Company had correctly interpreted M. Granet's letter. This question of interpretation was submitted in the first instance to the Council of the Prefecture of the Seine, which, on the 19th March, 1889, declared that M. Granet's letter had been rightly interpreted by the French Company. This decision was reviewed by the Council of State on the 1st May last, which set aside the order of the Court of Prefecture of the Seine, and determined that the letter in question had not the effect of an order compelling the French Company to break the contracts, but that it only amounted to an invitation to the French Company to take immediate steps to put itself right according to the conditions of its concession. Since the date of that judgment a correspondence has taken place between the French Company and its Government, from which it appears that the present Government would not sanction the joint-purse agreements. The case will now go back to the Court of Appeal, which will decide, and I hope finally, the amount of damages to which this Company is entitled through the unjustifiable conduct of the French Company, and we shall await the decision with great interest. I do not think you would expect me to express any opinion on the subject. There is no doubt that a gross breach of agreements was committed, but whether the French Court will see fit to give us considerable damages on that account or not, I shall not venture to predict. I think I have touched on every important matter which has arisen during the half-year, and I can only express a hope that when we meet again six months hence the prevailing depression in commercial circles, upon which our fortunes so much depend, will have disappeared, so that we shall be in a position to present to you a more satisfactory report than it has been in our power to do to-day. With these observations I beg to move the following resolution:—

"That the Report of the Directors and the accompanying Statement of Accounts to the 30th June, 1891, submitted to this meeting be, and the same are hereby, received and adopted."

The DEPUTY-CHAIRMAN (Mr. Francis A. Bevan) seconded the motion.

Mr. THOMAS SMITH (York) proposed an amendment, contending that the expenses in connection with the new offices which had been opened should not have been charged to revenue account. He wished to know what proportion of the loss of £8,432 in the traffics had occurred in the first three months in the year, as the Directors made this decrease an excuse for the paltry reduction in the dividends paid in May of 1s. per cent. on the ordinary, and 2s. per cent. on the preferred stocks.

The CHAIRMAN pointed out that he had stated that £10,000 had been lost through the Chilian interruptions.

Mr. SMITH, continuing, stated that the reductions which he had mentioned that had been made in the dividends compared with those paid on the 1st of May, had caused the market value of the Company's stocks to fall by between 3 per cent. and 4 per cent., amounting in gross to over £200,000. The Chairman had said that they had only been adding £5,000 a year to the renewal fund, but this was not correct. Whenever there was any increase in the traffic it was always added to the renewal fund. He maintained that the Directors were much to blame for reducing the dividends.

The CHAIRMAN: We can only pay what we have.

Mr. SMITH complained that charges had been made against the revenue account which should have been debited to the renewal fund, for the work which had necessitated these expenses was new, and was, therefore, he maintained, a capital charge.

The CHAIRMAN: Rent is payable out of revenue.

Mr. SMITH: You say you have put a special wire down which has been conceded by the French Government. The Directors had shown a great want of consideration to the shareholders' interests. There were, he said, many reasons why the Directors should see that their stocks were held in proper esteem on the market. He estimated the market value of the renewal fund at £1,050,000.

The CHAIRMAN said that the Directors estimated the value of the investments forming the renewal fund at £29,000 beyond their cost price.

Mr. SMITH said that he had had careful financial assistance in making his calculations. It was neither reasonable nor fair, he contended, that the cost of new offices should be charged to revenue. They were told that the renewal fund was required for new cables, and that their own were old and worn out; but it was stated in the report that their cables and land lines were in good working order. They knew, too, that wherever there was a fault it could be repaired, no matter the depth at which the cable lay. He suggested that 3½ per cent. should be the minimum dividend upon the ordinary stock this year. This would give the preference stock its full dividend and 1 per cent. to the deferred stock. He moved, as an amendment, that this dividend should be paid, and that, if need be, the renewal fund should be used for the purpose.

The CHAIRMAN, in answer to a question, stated that the amendment was not in order. The present was an interim dividend.

Mr. SMITH said that he would leave out of his amendment the recommendation as to dividend, and would move that the report be not adopted.

Mr. BRANDON seconded the motion, complaining that the deferred stockholders had received no dividend for seven years.

Mr. WREFORD also opposed the adoption of the report. They had, he said, been promised a dividend on the deferred stock whenever the renewal fund was worth more than £1,000,000.

Mr. JACKSON complained of the increase of the expenses under Abstract B—the expenses at the London office. Although the receipts had been £8,000 less, these expenses had been £1,208 more than they were in the December half-year. The expenses at the stations had increased by £1,689 over those of the December half-year, but this was reasonable, considering the new stations. He thought it was humiliating, with all the experience which this Company had had, that they should be beaten by their youngest competitor. He thought the Directors showed a recklessness as to the dividend which they paid. Lord Monck, who was for many years their Chairman, had led them to believe more than once that with liquid assets of £1,000,000 the interest of the renewal fund should be devoted to increasing the paltry dividends which the Directors, after so many years' work and experience, were able to offer them. For years 40 per cent. of their capital—the deferred stock—had received no dividend.

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Mr. GRIGGS said he could endorse what Mr. Jackson had said, that Lord Monck stated that when the renewal fund reached £1,000,000 the deferred stockholders should be taken into consideration.

The CHAIRMAN: I will now reply to the remarks and questions that have been put. Mr. Smith asked what proportion of the decrease in the traffic occurred during the first three months of this year. It is not very easy to give that information at this moment, but if he calls at the offices, Mr. Weaver will, no doubt, give him that information. He has announced his reason for rejecting the report upon certain grounds. One is that the cost of the new offices should have been taken from the renewal fund. Surely, the rent of offices is an item that can only be debited to maintenance? I think our auditors—who, by the way, are appointed by the shareholders for their protection—would at once point out the impropriety of debiting to capital what is a revenue charge. I presume that the auditors are here, and if they express an adverse opinion on that point I should be surprised. Another reason for Mr. Smith's opposition is that the full 3 per cent. dividend should be paid, which I connect with the remark about the renewal fund. Dividends should only be paid out of our net receipts, and that raises the question of the renewal fund.

Mr. SMITH: Has not the renewal fund been taken from the receipts?

The CHAIRMAN: Yes, but will you allow me to continue? Let me repeat what I said at the last meeting as to the the renewal fund, and I believe those remarks were received with satisfaction by the large majority of all who were present. I may say that the only complaint that I have received is one from a proprietor at a distance, who, in a letter, considered that I had hinted at the possibility of appropriating a portion of the renewal fund, or rather the interest on the renewal fund to dividend. That is the only complaint I have had upon the report. Now, gentlemen, this is what I said at our meeting in January:—"It is a very delicate subject, and involves a question of dealing with the renewal fund. It has always been recognised that £1,000,000 was the very least we should have at our credit, having regard to the age and condition of our cables, and the necessity some day or other of renewing them. At the same time if we were to go on laying by as much as we have done during this last year, I have no doubt the Directors would then take into consideration the possibility of placing less to the renewal fund. This last year we added £27,894 out of the interest, which amounted to about £31,500. Now, if we can go on at that rate for a year or two more, I have no doubt the matter would be open to consideration. Beyond that it is impossible for me to go, and even that I am saying as my own personal opinion." I have nothing whatever to add to those words. I believe that what was laid down there is the correct policy, and the policy which will commend itself not only to the preferred shareholders but also to the deferred shareholders, who have just as much interest in the proper maintenance of our cables in the Atlantic. Mr. Smith said that it cannot be true that the cables are old and worn out. Does he mean to say that our cables are going to "live" for ever? One of them was laid in 1869. Is not that old?

Mr. SMITH: It can be renewed. We have proved over and over again that our cables can be renewed.

The CHAIRMAN: The oldest of our cables was laid in 1869, the next in 1873, the next in 1874, and the youngest was laid in 1880. I say, in view of that and our experience of the Atlantic, that we are bound to keep a very handsome reserve in order to be quite able at any time to maintain our four cables in the Atlantic, to say nothing of our many small cables on the other side connecting with the land. Mr. Smith is a man of such knowledge and intelligence that it is almost incredible he should put forward the idea that a particular dividend should be paid notwithstanding the revenue we receive. Then, he complained of the fall in the market price of our stock; but I am not aware that our stock has fallen so very much. I do not think that it has fallen as much as many of the great railway stocks. As my friend Sir John Pender said, not long ago, what is remarkable about these investments in cable companies is the small fall—the slight depreciation—that has taken place. That is what is remarkable to me—not that our stock should have fallen from the highest point ever reached in recent times.

Mr. SMITH stated that the preferred stock had fallen 5 per cent.

Mr. WREFORD: And your deferred stock was 36, and is now 11.

The CHAIRMAN: Mr. Smith calculates our renewal fund to be of the market value of £1,050,000. We have taken the middle prices, and we make the rise in value of the investments to be £29,000, so that there is a difference between our calculation and Mr. Smith's of about £30,000. It would, be idle to suppose that we could realise our renewal fund in these days at even that middle price. I cannot think that the criticisms of Mr. Smith justify the rejection of our report. The reduction in our receipts is in proportion to the reduction in the receipts of the other Companies—and I believe our diminution is rather less. I think we might take some credit for what has been done in view of the figures that I have given to you. With reference to the expenses at the head office, Mr. Jackson complained that, under Abstract B, they are £1,200 more than last year, but I find on looking at the accounts that the net increase in the expenses under Abstract B, compared with the corresponding half-year in 1890, is only £140.

Mr. JACKSON observed that the total amount of the expenses under Abstract B last half-year was £5,807, while in the present half-year the amount was £7,015, or the difference which he had mentioned.

The CHAIRMAN: I have the exact figures before me, and they show that under Abstract B the net increase is £140. The increase under Abstract C is £1,766, but that is due to the increase in salaries and wages, maintenance of land lines and repairs and renewals of buildings; and I believe that the meeting generally will agree that the whole of these charges should be put to revenue.

Mr. JACKSON repeated that the total of the expenses under abstract B for the half-year to the 31st of December last was £5,807, whereas this half-year, to the 30th of June, the total was £7,015.

The CHAIRMAN: But you must compare the two corresponding half-years. Then you complained of the success of the Commercial Cable Company. Well, our duty is to do our best to reduce their success as much as possible, and that is what we are trying to do, and I think we have done something towards it this half-year. Mr. Jackson also noticed that there is a considerable credit balance not invested. That is always the case at the end of a half-year, but the money will be invested, of course, when realised.

Mr. JACKSON: I am satisfied that we are in the best hands.

The CHAIRMAN: I will not say more about the opinion expressed by Viscount Monck, further than that I am quite sure he is in accord with me and the Directors with reference to the absolute necessity of having not less than the sum I have mentioned at the credit of our renewal fund. I think Mr. Smith will admit that he has not made a very strong case, to say the least of it, against us, and I would ask him to withdraw his opposition.

Mr. SMITH regretted he could not do so.

The CHAIRMAN: Then you will vote against the resolution.

Mr. SMITH: I have moved that the report be not adopted, and that has been seconded by Mr. Brandon.

The CHAIRMAN: That is not an amendment.

Mr. SMITH: You may take it as you like, but that is what I have moved.

The CHAIRMAN then put the resolution in the usual way, and declared it carried by a majority.

Mr. SMITH: By what majority?

The CHAIRMAN: By a considerable majority.

Mr. BRANDON: I doubt very much if there was a majority.

The CHAIRMAN: The report was adopted by a substantial majority. The numbers were 13 to 6. That constitutes the business of the meeting.

Mr. FRY expressed his sympathy with some of the remarks which had been made, and "a sort of regret" that there had been no indication from the Chairman that the Directors had in view any policy that would benefit the proprietors. He proposed a vote of thanks to the Chairman.

Mr. JACKSON seconded the motion, which was carried unanimously.

The CHAIRMAN: We are very much obliged to you for your renewed confidence in us. I can assure you that we are doing all we can to improve the condition of your Company, and if business improves (and it will be very bad if it does not), we hope that we shall be able to present a more satisfactory report to you next time.

The proceedings then terminated.

Cuba Submarine Telegraph Company (Limited).

The following is the report of the Directors for the half-year ended 30th June last, to be presented at the fortieth ordinary general meeting of shareholders, to be held at the Company's offices, 58, Old Broad-street, E.C., on Wednesday, the 12th inst., at 12 o'clock:—

From the accounts it will be seen that the gross receipts (including the balance brought from last account) amount to £23,586. 2s. 1d., and the gross expenditure (including the half of the annual payment on account of the 1881 cable, and the expenses in connection with cable repairs) to £10,997. 6s. 3d., leaving a sum of £12,588. 15s. 10d. to the credit of revenue account. Of this the sum of £2,656. 5s. 10d. has been added to the reserve fund, which now stands at £78,000. The dividend on the preference shares will absorb £3,000, and leave £6,932. 10s., out of which the Directors recommend the payment of a dividend on the ordinary shares at the rate of 8 per cent. per annum, free of income tax, the balance, £532. 10s., being carried forward to the current half-year's account.

The Company's engineer, Mr. Keith, who superintended the submersion of the new cable between Batabano and Cienfuegos, reports that it was well laid, and has been tested with satisfactory results. The Cienfuegos-Santiago 1875 cable, which became interrupted on January 13th, as mentioned in last report, was restored to working order on February 3rd, while the Batabano-Cienfuegos 1870 cable, which was broken on February 22nd, was repaired on March 28th. These repairs were economically carried out by the Company's engineer, and the whole cost is charged against the revenue of the half-year. The Cienfuegos-Santiago 1881 cable, referred to in paragraph 6 of the last report, has been repaired at the cost of the contractors.

The whole of the Company's submarine system is now in duplicate and in good working order. The suit against the Spanish Government for the protection of the Company's concession is progressing, and the full statement of the Company's case has been lodged with the Contencioso Court.

The Directors have, with much regret, to announce the death, on 22nd February, of Mr. Horatio J. Perry, who had been a Director from the commencement of the Company, and had well served its interests at Madrid. Mr. Charles Woodbyne Parish has been appointed in his place. The Director who retires from the Board at this time is Mr. Thomas Greenwood, who, being eligible, offers himself for re-election. Mr. John Gane, the auditor, also retires, and offers himself for re-election.

City and South London Railway Company (Limited).

The following is the report of the Directors to be submitted to the half-yearly ordinary general meeting of the Company, to be held at Winchester House, Old Broad-street, London, E.C., on Tuesday, August 11, 1891.

In presenting their report and statement of accounts for the half-year ended June 30, 1891, the Directors have to report with satisfaction that the railway has been worked, during that period, without accident to any passenger or to any of the staff employed. Although occasional delays to the traffic have occurred through defects in the rolling stock, or other

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similar causes, these were at first to be expected during the working of a new and untried system of locomotion, and it is a matter for congratulation that in all these cases the delay has been of very short duration, and the regularity of the working is steadily improving.

The receipts during the half-year from all sources amount to £19,688. 2s. 4d., and the expenses for the same period to £15,520. 16s. 5d., leaving a net profit of £4,167. 5s. 11d. The net revenue account shows a balance of £4,693. 3s. 8d., of which amount the interest on debentures absorbs £4,137. 16s. 6d., leaving a balance of £555. 7s. 2d. to be carried forward to the next account.

In the beginning of a new undertaking, many of the items of expenditure are necessarily high, but your Directors have satisfaction in stating that some of these have already been considerably reduced, and further reductions will, from time to time, be made, so far as is consistent with the safety of the public and the interests of the Company.

During the half-year the number of passengers carried by the railway has been 2,412,343. For a considerable time a uniform charge of twopence for passengers was adhered to, but it has been found necessary, in order to compete with the omnibus and tramway traffic, to reduce the charge at certain stations to one penny during stated hours. This has been found to work advantageously, both in the Company's interest and to the convenience of the public.

Two additional locomotives are now nearly ready, and one train of the new carriages has already been received. The completion of these, and the additional generating engine and dynamo now in course of construction, will allow of a considerable increase in the train service.

The action taken by the London County Council, in November last, to contest the right of the Company with respect to the line of frontage at Kennington and the Oval stations has been decided in favour of the Company by the Court of Appeal.

The Bill promoted by the Company in Parliament for an extension of the line to Islington failed to pass the Committee of the House of Commons, and the Directors regret that a valuable aid to the traffic of the existing line and a great accommodation to the public has been in consequence delayed.

Your Directors regret that, owing to other engagements, Mr. Walter Robinson has decided to resign his seat at the Board, and the vacancy so created has been filled by the election of Mr. S. Barclay Heward, of 57, Old Broad-street, London.

NEW COMPANIES, STATUTORY RETURNS, &c.

ELECTRICAL ASSETS PURCHASE COMPANY (LIMITED).—This Company was registered on July 28, 1891, with a capital of £1,000 in £1 shares, by Messrs. Robinson and Stannard, 19, Eastcheap, E.C. The objects are: To purchase the whole of the assets and effects of the Liepmann Carbon Company (Limited), including its British and foreign patents for "Improvements in the manufacture of carbons for electric lighting," to work the said invention, to manufacture carbons for electric lighting purposes, in the form of rods, discs, plates, tubes, or otherwise, and generally to carry on the business of electricians and electrical engineers. The number of the Directors is not to be less than two, nor more than five; remuneration as fixed by the Company at the general meeting, provided that, in addition, they receive a fee of 10s. 6d. for each meeting. Office, Eastcheap Buildings, 19, Eastcheap, E.C.

EPSTEIN ELECTRIC ACCUMULATOR COMPANY (LIMITED).—This Company was registered on the 31st July, 1891 (with a capital of £101,000, divided into 100,000 ordinary and 1,000 founders' shares of £1 each) by A. L. Foley, Marsemore-mansions, South Hampstead. The objects are: To acquire the patents and patent rights of Mr. Ludwig Epstein relating to the invention of and improvements in the manufacture and use of secondary or storage batteries; to manufacture secondary batteries under the said patents or patent rights, or according to the said invention or any improvements thereon; to carry on the business of an electric light company in all its branches; to construct, lay down, establish, fix, and carry out all the necessary engines, wires, cables, lines, accumulators, lamps, and electric plant or apparatus; to generate, accumulate, distribute, and supply electricity for the lighting of cities, towns, streets, docks, markets, and places public and private; and to carry on the business of electricians, electrical contractors, electrical and mechanical engineers, merchants, bankers, brokers, shippers, shipowners, &c. The first subscribers are:—

	Shares.
Sir J. D. Mackenzie, Bart., Worcester-park, Surrey	1
H. G. Rawson, 6, Pump-court, Temple	1
L. Epstein, 5, Cambridge-villas, East Twickenham	1
J. Maier, Ph.D., 23, Melrose-gardens, W.	1
G. T. Broadbridge, 55, Doddington-grove, Kennington-park, S.E.	1
F. Harland, 69, Lavender-sweep, Clapham-common	1
J. Davies, 46, Derby-road, Croydon	1

The number of Directors is not to be less than three, nor more than 12, the first to be appointed by the subscribers. The remuneration of the Board of Directors will be determined by the Company, from time to time, in general meeting.

"ENERGY" GAS, ELECTRIC LIGHTING AND POWER COMPANY (LIMITED).—This Company was registered on the 1st August, 1891, with a capital of £20,000 in £1 shares. The objects are to apply for purchase or otherwise acquire patents, licenses, or other rights in connection with inventions having for their object the giving of new qualities to gas or the suppressing of its defects, and particularly the making of gas cheaper and giving it the appearance of electric light. To create a lighting industry having the qualities of electricity without the disadvantages of either. To carry on the business of manufacturers of and dealers in incandescent lights, and generally that of a Gas, Electric Lighting and Power Company. The subscribers, each of whom takes one share, are Eugene Destruels, Albert Daude, Joseph Louis, Paul Fernand, Attmar Kern, Paul E. Sautreau, and Thiebaut Apfler, all of Paris. Registered by A. Herbelet, 5, Chancery-lane, W.C., without Articles of Association.

FIELD'S "M.P." DEVELOPMENT ASSOCIATION (LIMITED).—This Company was registered on July 28, 1891, with a capital of £100,000 in £1 shares, by Hays, Schmettan and Co., 31, Abchurch-lane, E.C. The objects are: To purchase, take over, and work the whole of the patents mentioned in the Memorandum of Association, 49 in all, granted in or applied for and not yet issued. British (5), Belgium (3), Austria (2), Brazil (2), Canada (2), Italy (2), France (3), Germany (2), Luxemburg (2), New South Wales (2), New Zealand (2), United States (4), Queensland (2), South Australia (2), Spain (2), Switzerland (2), Denmark (2), India (2), Victoria (2), Norway (2), Sweden (2). To carry on, *inter alia*, the business of an electric light company in all its branches, to construct, lay down, establish, fix and carry out all necessary cables, wires, lines, accumulators, lamps and works, necessary for the generation, accumulation, distribution, and supply of electricity, and to carry on business as engineers, boiler makers, dealers in engines, boilers, motors, iron, steel, copper and other metals, electricians, electrical engineers, contractors for electric lighting, merchants, bankers, brokers, shippers, or otherwise. The number of Directors is not to be less than three, nor more than nine, the first to be elected by the subscribers to the Memorandum of Association. Qualification: 250 shares. The Board of Directors, exclusive of Managing Directors, are entitled to a remuneration of £1,500 per annum, to be divided as they themselves may determine.

WATER METER AND GENERAL TRADING SYNDICATE (LIMITED).—This Company was registered on the 28th July, 1891, with a capital of £15,000 in £1 shares, by J. A. Weston, 526, Mansion House Buildings, 11, Queen Victoria-street, E.C. Objects (amongst others): To construct, originate, conduct, contract for, develop, manage, control and work scientific, electric, telegraphic, telephonic, tramway, and other industrial undertakings, and to promote and establish companies or private undertakings with objects similar to the above. Registered without Articles of Association. Office: 526 and 527, Mansion House Buildings, 11, Queen Victoria-street. E.C.

BIRMINGHAM ELECTRIC SUPPLY COMPANY (LIMITED).—The annual return of the above-named Company, made up to the 10th June, 1891, was filed on the 7th July, 1891. The Company, which was registered on the 2nd December, 1889, has a capital of £100,000 in £5 shares; 10,006 ordinary and 1,800 special issue shares have been taken up, and upon all of the former the full amount has been called, while upon all of the latter 5s. per share has been called. The calls paid amount to £49,597. 10s., and unpaid to £882. 10s. Office, 14, Dale End, Birmingham.

METROPOLITAN ELECTRIC SUPPLY COMPANY (LIMITED).—The annual return of this Company, made up to May 13th, was filed on May 22nd last. The Company has a nominal capital of £500,000, divided into 49,900 ordinary and 100 founders' shares. 45,932 ordinary and 100 founders' shares have been taken up, making a total of 46,032. Upon 43,900 of these £9 per share has been called, and upon the remainder the full amount has been considered as paid. The calls paid amount to £392,500. 9s., unpaid to £2,599. 11s., and the amount considered as paid is £21,320. Office: Winchester House, Old Broad-street, E.C.

WEST COAST OF AMERICA TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to May 29th, was filed on June 4th last. The nominal capital is £300,000, in £10 shares, all of which have been taken up, on each of which the full amount has been called, and all calls are paid. Office: 120, Cannon-street, E.C.

WILLIAMSON ELECTRICAL AND ENGINEERING COMPANY (LIMITED).—At an extraordinary general meeting of the above-named Company, held at 14, St. Ann's-square, Manchester, on July 3, 1891, the following special resolution was passed, and at a subsequent meeting held on July 21, 1891, duly confirmed:—"That the capital of the Company be increased to £25,000 by the creation of 2,000 new shares of £10 each." The notice of the meeting was filed on the 28th July, and the statement pursuant to Section 2 of the Customs and Inland Revenue Act, 1888, on July 31, 1891. Office, 14, St. Ann's-square, Manchester.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the past week amounted to £5,152.

CITY AND SOUTH LONDON RAILWAY COMPANY.—The traffic receipts of this Company for the past week amounted to £692.

CUBA SUBMARINE TELEGRAPH COMPANY.—The estimated traffic receipts of this Company for the month of July were £3,100, as compared with £3,134 in the corresponding month of last year, showing a decrease of £34.

DIRECT SPANISH TELEGRAPH COMPANY.—The traffic receipts of this Company for the month of July, 1891, amounted to £1,667, as against £2,016 in the corresponding period of last year, or a decrease of £349.

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EASTERN TELEGRAPH COMPANY.—The traffic receipts of this Company for the month of July, 1891, amounted to £52,303, and to £54,224 in the corresponding period of 1890, a decrease of £1,921.

EASTERN EXTENSION TELEGRAPH COMPANY.—The receipts of this Company for July amounted to £41,219, as against £46,367 in the corresponding period of last year, showing a decrease of £5,148.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of this Company are as follows:—Receipts in July, 1891, £24,400; 1st January to 31st July, 1891, £165,800; corresponding months, 1890, £156,000; corresponding months, 1889, £154,200. The reduction in the rates, which was agreed upon at the Telegraph Conference in Paris, came into force on the 1st of July. The Company's new cable between Denmark and France was successfully laid during the month.

P. AND J. MACLELLAN (LIMITED).—The Directors have declared an interim dividend of 6s. per share on the preference shares, being at the rate of 6 per cent. per annum, payable on the 11th August.

A. AND J. STEWART AND CLYDESDALES (LIMITED).—The Directors have resolved to pay an interim dividend at the rate of 6 per cent. per annum on the preference shares (less income-tax) and at the rate of 8 per cent. per annum on the ordinary shares, free of tax, for the half-year to June 30, 1891, to shareholders standing registered in the books at July 30, 1891.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the weeks ended July 17th and 24th, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were respectively £2,280 and £3,319.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The traffic receipts of this Company for the month ended July 31st were £2,075.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The receipts of this Company for the half-month to July 31st amounted to £2,058, as compared with £2,702 for the corresponding period last year, showing a decrease of £644.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, July 29.	Price Wednesday, August 5.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending August 5.	
						£ s. d.		Highest.	Lowest.
			TELEGRAPHS.						
£1,300,980	Stock	12/0	Anglo-American ..... xd	44 45	43 44	6 7 9	Jan., Apr., July, Oct.	43¾	43
£2,849,510	Stock	24/0	Do. Preferred ..... xd	83½ 84½	82 83	6 14 11	" "	83⅝	82½
£2,849,510	Stock	5/0	Do. Deferred	9½ 10	9½ 10	..	.. ..	10	9⅝
£250,000	100	4%	African Direct, Telegraph 4% Debentures	98 101	98 101	3 19 3	January and July ..	98	..
130,000	£10	5/0	Brazilian Submarine	11⅝ 12½	11⅞ 12½	6 18 9	Mar., June, Oct., Dec.	12½	12
£69,200	£100	5%	Do. 5 per Cent. Bonds ..... xd	101 104	99 102	4 16 2	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107	103 107	4 13 6	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	105 109	105 109	6 3 10	April and October ..	107⅞	107½
16,000	10	8/0	Cuba Submarine	10½ 11½	10¼ 11½	6 19 2	February and August	..	..
6,000	10	10%	Do. Preference 10%	17 18	17 18	5 11 1	" "	..	..
12,931	5	3/2½	Direct Spanish (£4 paid)	3½ 4	3⅝ 4¼	7 0 0	April and October..	3⅞	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States ..... xd	10½ 10⅝	10⅜ 10⅝	6 10 3	Jan., Apr., July, Oct.	10⅞	10½
400,000	10	5/6	Eastern	14⅝ 15¼	14⅝ 14⅝	4 5 11	" "	14⅞	14⅝
70,000	10	6%	Do. 6 per Cent. Preference ..... xd	15 15½	15 15½	3 17 5	" "	15½	15
£1,200,000	Stock	6%	Do. 4 per Cent. Mort. Debenture Stock.... xd	106 109	106 109	3 13 5	May and November	..	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899 ..... xd	107 110	105 108	4 10 11	February & August	109	..
250,000	10	2/6	Eastern Extension	14⅜ 15½	14⅜ 15	4 12 7	Jan., Apr., July, Oct.	15 1/16	14⅜
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock ..... xd	105 108	104 107	3 14 1	February & August	..	..
£85,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	101 104	102 105	4 16 2	January and July ..	104½	104
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900 ..	101 104	101 104	4 14 4	" "	102⅛	..
180,227	10	4/6	Globe Telegraph and Trust ..... xd	9⅜ 10	9⅜ 9⅝	5 10 0	Jan., Apr., July, Oct.	9⅝	9 1/16
180,042	10	6%	Do. 6 per Cent. Preference ..... xd	15 15½	14⅝ 15⅛	3 18 8	" "	15⅛	14⅜
150,000	10	5/0	Great Northern	18½ 18⅝	18⅛ 18⅜	4 10 8	Jan., April, and July	..	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105 108	105 108	4 12 7	March & September	..	..
17,000	25	37/6	Indo-European	39 41	39 41	4 11 3	May and November	..	..
38,348	10	5/0	London Platino-Brazilian	6½ 7⅛	6½ 7⅛	6 0 0	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106 109	106 109	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's	8 8½	8 8½	4 14 1	April and October..	..	..
3,381	£100 Cert.	£1	Submarine Cables Trust 6%	115 120	115 120	5 0 0	" "	..	..
15,609	10	6/0	West African Telegraph	8 9	8 9	5 11 1	January and July ..	..	..
£281,400	100	5%	Do. 5 per Cent. Debentures	96 99	96 99	5 1 0	March & September	..	..
30,000	10	2/0	West Coast of America	3 4	3 4	..	January and July ..	..	..
£150,000	100	8%	Do. Debentures 8% 1902	97 102	97 102	7 16 10	June and December	97½	..
88,321	10	9d.	West India and Panama	1½ 2⅛	1⅜ 2⅛	..	..	1⅜	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10 10½	10 10½	5 14 3	May and November	..	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9 10	9 10	6 0 0	" "	..	..
61,683	15	9/0	Western and Brazilian	10⅜ 11⅛	10⅜ 11⅛	6 13 4	" "	11	..
30,364	7½	1/6	Do 5 per Cent. Cumulative Preferred	6¾ 7	6¾ 7	5 7 3	—	6¾	6¾
30,364	7½	7/6	Do. 5 per Cent. Deferred	4¼ 4⅜	4¼ 4⅜	..	..	4⅜	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910 ..xd	104 107	101 104	5 12 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910 xd	103 106	100 103	5 13 2	" "	106	105½
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	117 122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	101 105	101 105	5 14 3	March & September	..	..
			TELEPHONES.						
224,850	14/0	0/5½	Consolidated Telephone Const. & Maintenance...	7/16 9/16	7/16 9/16	7 9 4	May and November	..	..
220,000	£1	4/76	Oriental (11s. paid)	13/16 15/16	13/16 15/16	6 3 11	Yearly	..	..
438,984	5	3/6	National	4⅜ 5	4⅜ 4⅝	6 0 0	June and December	4 1/16	4 1/16
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½ 13½	12½ 13½	4 8 11	" "	12⅝	..
15,000	10	6%	Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd) .	12½ 13	12½ 13	3 14 1	" "	..	..
350,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd)	105 107	105 107	4 4 1	..	106⅛	106
58,000	5	1/0	United River Plate	2 3	2 3	..	January and July ..	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85 95	85 95	5 5 8	..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
1,000	£50	..	City of London Electric Lighting (£50 fully paid)..	60 62	60 62	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	4½ 5	4½ 5	..	..	..	..
5,322	£5	..	House to House Electric	4½ 5½	4½ 5½	..	..	..	..
30,000	£5	..	Liverpool Electric Supply (£3 paid)	2½ 2⅞	2⅝ 2⅞	3 13 1	..	..	..
111,000	5	..	London Electric Supply	1⅞ 2	1⅞ 2	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	9½ 10½	9½ 10½	4 7 7	..	10	9⅛
7,730	£5	3/6	St. James' and Pall Mall	6⅝ 6⅞	6⅝ 7	—	..	6 1/16	..
..	..	7%	Do. 7% Preference	3⅝ 3⅞	4¼ 4⅜	—	..	..	..
42,853	5	..	Westminster Electric Supply (£5 paid)	4⅛ 5⅛	4⅛ 5⅛	..	..	5⅛	5
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	..	Brush Electrical Engineering	2⅜ 2⅝	2⅜ 2⅝	..	..	2⅝	2 1/16
60,996	2	6%	Do. 6 per Cent. Preference	1⅞ 2	1⅞ 2	6 0 0	June and December	1⅞	1⅞
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares.... xd	4 5	4 5	7 0 0	January and July ..	..	..
17,180	5	..	Edison and Swan United	.. ..	.. ..	..	—	..	..
45,000	10	6%	Electric Construction	3 4	3½ 4½	..	—	4	3 7
70,000	2	10/0	Elmore's Patent Copper Depositing	3½ 3⅞	3⅞ 4	..	—	4 1/16	3
20,000	5	..	Fowler-Waring Cables (£4 paid)	2 3	2 3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works ..	18½ 19½	19 20	5 2 7	February & August	19	19
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103 105	103 105	4 5 9	March & September	..	..
11,334	£10	6/5	International Okonite Limited Ordinary	7½ 8½	7½ 8½	11 15 8	..	..	..
11,334	£10	5/0	Do. Preference	9½ 9⅝	9½ 9⅝	8 4 1	..	..	..
78,949	5	2/1½	Swan United (£3. 10s. paid)	4½ 5	4½ 5	6 19 10	May and November	4⅝	..
37,350	12	12/0	Telegraph Construction and Maintenance	44 46	44 46	5 4 9	March and July.....	..	..
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101 104	101 104	4 16 2	January and July ..	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£3 paid)	2⅛ 2⅝	2½ 2⅝	..	..	..	..
—	£5	..	Do. Preference (fully paid)	3⅞ 4⅛	3⅞ 4⅛	..	..	..	..
			RAILWAYS.						
50,000	£10	..	City and South London Railway	4 5	4 5	—	..	..	..

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NOTES.

Although the results of the first half-year's working of such a novel concern as the City and South London Railway are not to be taken as a criterion of its ultimate possibilities, the great interest which is everywhere taken in this experiment warrants a somewhat close examination of the figures which were placed before the shareholders on Tuesday. Since the opening of the line no less than 2,412,343 passengers have been carried, and 141,408 train miles have been run. The receipts per train mile from all sources during the half-year ended on June 30th have been a trifle over 2s. 9d., against the Metropolitan Company's average of 7s. The number of passengers carried per train mile comes out at 17, against 43 in the case of the Underground. It is to be remembered, however, that the trains on the Metropolitan Railway are more capacious than those on the electric line. The receipts from all sources amounted to £19,688, to which sum passengers contributed £19,403. The total expenses for the same period have been £15,520, leaving a net profit of £4,168 for the half-year. To pay 5 per cent. for the half-year on the capital actually expended up to date would require some £20,000.

The Directors of the City and South London Railway have, therefore, no light task before them. A reduction of the working expenses, which are at present over 78 per cent. of the gross receipts, to the normal figure of 50 per cent., and an increase in the revenue, are imperative, if the public are to be satisfied that electricity can pay. The latter desideratum will probably be partially attained so soon as there is the promised regular and rapid and comfortable three minutes' service; but extensions North and South will, in the end, have to be made before the City and South London Railway is as prosperous as we all wish to see it.

The resolutions which were passed at the meeting of the Electrical Trade Section, on Friday last, represent pretty accurately the prevailing feeling on the subject of electrical exhibitions in general, and the proposed one at the Crystal Palace in particular. The bands, coloured lights, and toys attract the shilling-paying public, and enable the promoters of these shows to sometimes score a success, but something more solid is required to attract *customers*. Now, it is to the customer that heavy electrical engineering firms look to recoup themselves for the expense inevitably attendant on exhibiting, even when the exhibitors, as at the Crystal Palace, are not to be mulcted for floor space. The promoter and the exhibitor, as Mr. Crompton said on Friday, therefore, regard the matter in a somewhat different light.

Such being the case, it is not surprising to find that the Directors of the Crystal Palace Company intend to go on with their Exhibition, although they have decided to postpone the date of opening until January 1, 1892, and no one can blame them. No less than 56 firms have, they say, already applied for space. There will be the usual disproportionate representation of young and pushing firms, and plenty of coloured lights, art fittings, electric bells and telephonic "auditions," and last, but not least, the phonograph. The public will pay their shillings, and all will be well—from the Directors' point of view. But the heavy engineering firms, the backbone of the electrical industry, will have no time to prepare worthy exhibits, and a thoroughly national and representative Exhibition, such as alone might benefit them, is not, therefore, probable.

There was one feature of last Friday's proceedings which is worthy of notice, namely, the manner in which electric lighting alone was apparently thought of by the Crystal Palace Directors. Since the Exhibition of ten years ago, to which they referred with such natural pride, electric lighting has become a comparatively routine business, even in this country, and in an Exhibition thoroughly representative of the state of the industry, transmission and distribution of power, electric traction, electric haulage, and electric pumping should almost overshadow the lighting exhibits.

There is much to be said for the usefulness of non-mathematical speculation for a pioneering expedition into the unknown land of ether theories and the *vera causa* of electrical phenomena. The subject is so complex and obscure that to endeavour to map out the country on elaborate geodetical principles is not only extremely laborious, but the landmarks are so rare, and the intervening jungle is so dense, that progress must be both tedious and uncertain. A sketch map contains a good deal of information of a common-sense order, though the bearings may be erroneous, while a trigonometrical network, though marvellously accurate, is of little use to a traveller. Mr. Tolver Preston has made many speculative advances of this kind, and the article which we print in another column contains, without any attempt to dogmatise, much that is suggestive. It is time enough to dogmatise when the subject has become ripe for mathematical treatment, and when theory has been verified by ex-

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periment. The author is undoubtedly correct in thinking that an inelastic ether is unintelligible, but he goes further than the ordinary idea of shearing, and asks that the ether may be "to some extent compressible." But the "ether rarefaction" plays so important a part in these interesting "rough ideas," that we do not think the objections to this hypothesis are so trifling as is assumed.

WHILE modern physics teach that the old ideas of potential energy cannot be held to exclude and to be the opposite of kinetic energy, it is not safe to set up important distinctions between dynamical and statical phenomena, but the idea of treating waves as stationary appears to be useful as a working hypothesis. The figures given by Mr. TOLVER PRESTON, showing that 7,000 H.P. transmitted at the velocity of light (which it must be if the ether comes into play at all) demands a stress of only 26 or 27 grains, are very interesting, and serve to show the great difficulty of measuring or even detecting energy flow on a moderate scale.

ACCORDING to MAXWELL'S electro-magnetic theory, electric waves are propagated with the same velocity along conductors as through the air. Several of the earlier experiments of Prof. HERTZ seemed, however, to point to a different conclusion, and a considerable amount of discussion has lately taken place, chiefly among French physicists, in connection with the subject. Some important errors in interpreting the experimental results have been pointed out, and MM. LECHER, SARASIN, and DE LA RIVE have made further experiments, the results of which seem decidedly to show that the two velocities are the same. Prof. HERTZ, in a short article which we publish in this issue, declares that this has been his conviction all along, in spite of the fact that many of his experiments gave a contrary result. He points out that laboratories of ordinary dimensions are too small for properly carrying out investigations of waves of the great length usual in electric oscillations. When shorter waves of about 30 centimetres or less are used, no discrepancy between the two velocities has ever been found to occur.

THE rotary current system, to call it by the most commonly used of its many aliases, seems likely to give rise if not to a fine crop of lawsuits, that invariable concomitan of every electrical invention of value, at any rate to a vigorous controversy as to its true originator; indeed, according to Prof. DU BOIS-REYMOND, whose interesting communication to the *Electrical World* of New York we reprint in another column, "the question of who deserves the credit of being the only original inventor of electro-magnetic rotation is at present being ventilated with great ardour among the technical public all over Europe." At the present moment Prof. FERRARIS and Mr. NIKOLA TESLA, or rather their respective advocates in the technical Press, are contending as to the priority in discovering the principle, and probably the question which is being "ventilated with great ardour" on the Continent is whether BROWN or BRADLEY, DOLIVO VON DOBROWOLSKY or HASELWANDER, was the first to apply in a practical manner the principles first clearly enunciated by Prof. FERRARIS and to develop the first rough motor made by Mr. NIKOLA TESLA.

As far as England was concerned, and judging by our own order of publication, there was something approaching absolute simultaneity between the two workers, situated, as Prof. DU BOIS-REYMOND remarks, with "a few thousand miles of land and sea between them." In an editorial note, which appeared in *The Electrician* of May 25, 1888, we remarked: "In another column will be found an account of a highly interesting and ingenious device of Prof. FERRARIS, who, by means of the combination of two alternating fields displaced by a quarter phase, obtains the practical equivalent of a rotating field. That the device will readily lend itself to the construction of an alternate current meter is almost certain, but whether it will make a practical motor it is yet too early to speak with confidence. There can be little doubt, we think, as to the novelty of the idea, so far as regards previous publication; and yet we hear this week from America of a device which, so far as our information at present goes, seems to bear a good deal of similarity. This latter invention is due to Mr. NIKOLA TESLA, and he was to have read a Paper on the subject before the American Institute of Electrical Engineers on the 16th of the present month. One of the Transatlantic journals has already published an article, based, evidently, upon the patent specification, but we must confess that we are unable to make head or tail of the details." In our issue of June 15, 1888, we published the paper of Mr. NIKOLA TESLA referred to above.

IT is with pleasure that we find ourselves in perfect accord with Prof. DU BOIS-REYMOND as to the futility, except for the baneful purposes of patent litigation, of these disputes regarding priority. No two individuals will probably agree as to the respective value of actual publication in a monograph and potential publication by filing an application for a patent, but we think that everyone who has followed the history of this, the latest, development of alternate currents will be of opinion that there never was a clearer case of independent and simultaneous discovery of the same thing. If Prof. FERRARIS enunciated the principle more clearly, Mr. NIKOLA TESLA gave a more practical turn to the motor; and the names of FERRARIS and TESLA should be linked together in honourable union in history. Of course, the ingenious minds, with the bump of historical research abnormally developed, will not take kindly to this solution of the difficulty, but will continue to hunt down the "absolutely first," who, truth to tell, rarely exists, and, when he does, seldom repays the time devoted to the research. To this eagerness for priority may, indeed, be attributed the many immature Papers with which the scientific world is frequently regaled—Papers published in a hurry to "take date."

AT the moment of going to press we received the following telegram from our Glasgow correspondent:—

"At the meeting of the Town Council to-day (Thursday) Councillor Bell, Convener of the Electric Lighting Committee, stated that the Committee had resolved to take the advice of Sir William Thomson regarding various matters which had recently cropped up, and which were of vital importance to the question of the electric lighting of Glasgow. Under the circumstances he respectfully requested Councillor Colquhoun to delay his motion for rescinding the resolution of a former meeting regarding the adoption of the low-tension system in Glasgow. Councillor Colquhoun had great pleasure in acceding to the wish of the Committee that his motion should be postponed."

The whole question of the system to be adopted in Glasgow seems, therefore, likely to be re-opened.

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Cork.—The Directors of the Cork Gas Consumers' Company contemplate seeking powers to supply electric light.

East African Telegraphs.—The German Government has decided, says a Berlin telegram, to establish telegraph lines along the whole of the German East African coast.

University College of South Wales.—The Council of this College is prepared to appoint a Professor of Mining. Further particulars will be found in our advertisement columns.

Erding (Bavaria).—Tenders are invited for the supply of the necessary plant for the electric lighting of this town. Water-power to the extent of 60 H.P. is available.

Projected Electric Railway between Baden and Voslau.—Messrs. Ganz and Co. have obtained the concession for constructing an electric railway between Baden and Vöslau.

New Cable between England and Germany.—The laying of a new cable between Bacton, near Lowestoft, and Emden, at the mouth of the Ems, has been completed by the cable ship Faraday.

Holborn District Board.—At the last meeting of this Board a letter was read from the County of London Electric Lighting Company, stating that they intended to apply for a Provisional Order.

Cambridge.—The Town Clerk has received an official intimation from the Local Government Board that a fresh inquiry will be held as to the desirability of granting the Electric Lighting Loan.

Manchester Technical School.—Premises have been taken by the Council of this School for the purpose of establishing a practical training school of electrical engineering. The school is to be ready during the coming winter.

Maidstone.—At a private meeting of the Local Board, on Tuesday, the question of supplying the town by electricity was considered, and it was resolved to apply for a Provisional Order, and, if possible, to put the supply into the hands of an electric lighting company.

The Victorian Electrical and Telegraphic Journal.—The editors of this journal announce in their June issue that with their July number the publication of the journal will come to a close. It was first published in August, 1886, and has made a regular monthly appearance ever since.

Old Students' Association.—The Committee of this Association announce that a garden-party (tennis and music) will be held in the grounds of Glebe Lodge, Champion Hill, on Saturday, September 5th, from 3 to 7 o'clock. Tickets (2s. 6d. each) may be had of Messrs. W. B. Esson, C. E. Holland, or Reginald Jones.

Chicago Exhibition.—Sir Henry Trueman Wood has been instructed by the Council of the Society of Arts to at once visit Chicago, and he will leave England for this purpose early in September. Exhibitors likely to require special arrangements made for them are requested to communicate with him before his departure.

Electric Construction Corporation.—The Managing Director of this Corporation (Mr. Ebb-Smith) has resigned his official position, and has been elected to the seat on the Board vacated by the decease of Sir R. N. Fowler, Bart. Mr. Thomas Parker, the present Works Director, will in future act as General Manager of the Corporation.

The Dyne.—According to Mr. John T. Grier, in the *Electrical Engineer* of New York, "we may roundly define a dyne in language that will be more likely to stick to the memory and be more easily grasped by some if we slightly paraphrase the definition and say it is that force which, acting for one second on a mass of matter equal in weight to four-tenths of a dime, gives to it a velocity of almost four-tenths of an inch per second."

Liverpool Overhead Railway.—At the half-yearly meeting of the Liverpool Overhead Railway Company, on Tuesday, Sir W. Forwood stated that considerable progress has been made with the line during the past half-year, no less than £85,620 having been expended, out of a total expenditure up to date of £143,098. The Directors, he said, had finally decided to use electricity as the motive power, and a contract with the Electrical Construction Corporation to work the line for two years at 3½d. per train mile for locomotive expenses had been concluded. The line would probably be opened in the spring.

Accident on the Lichterfeld Electric Railway.—An accident occurred on this line on the 25th ult. About half-past eight the car left the Potsdam station, but when a little way out it came to a standstill, owing to the cessation of the supply of current. The conductor left the car in order to ascertain the cause of this, and returned to the station. In the meantime, however, the car also started towards the station. It ran through the buffers at the end of the line, and was brought to rest by the wheels sticking in the soft earth. Apparently no one was hurt, and the car was soon able to be run again.

The Effect of Electric Light on Fish.—"Duty," says a correspondent to *Land and Water*, "took me to Totland Bay a short time since. In answer to my inquiries about the sea-fishing, I was told that the fishing all along that part of the Isle of Wight was very poor, and that since the setting up of the search light for the forts it had become worse. I also heard that there used to be a very good place for fish near the lighthouse at St. Catherine's Point, but that the electric light had driven them all away, and now it was quite useless putting out nets in a spot where a few years since a decent haul was looked on as a certainty."

Helston.—At a recent quarterly meeting of the Town Council, the proposed electric lighting of the borough was further discussed. Mr. J. E. Veale, of St. Austell, presented a report on the subject, in compliance with the request of the Special Committee which had been appointed to consider it. He declared that it was quite possible to light the town by electricity, and that the present disposition of the town lighting would adapt itself well to the new illuminant. Mr. Dale moved that the Council decide upon lighting the borough by electricity, and that water power be used for the purpose, the details to be left to a Committee. The resolution was carried.

The St. Pancras Central Station.—The Electricity Committee of the St. Pancras Vestry inspected the electrical works on July 30th, and found that four engines and dynamos had been erected. As to the work of main laying, the Committee report that it is proceeding rapidly. At the Cobden sub-station good progress is being made. The Committee are about to issue advertisements for the staff of officers. The proposed staff for the works consists of a resident enginner, at £4 per week; two engine drivers, at £3 per week; two dynamo attendants, at £3 per week; inspector of private works, £2.10s. per week; six stokers, at 25s. to 35s. per week; storekeeper and attendant at sub-station, care of arc lights, &c., 35s. per week.

Thunderstorms.—During the past week or ten days the usual crop of thunderstorms has occurred in various parts of the United Kingdom; considerable injury being done to life and property. On the 3rd inst., an agricultural labourer was killed by lightning near Lincoln. On the 4th, during a heavy thunderstorm which passed over St. Helens, the York Hotel was struck. The chimney stack was damaged, the paper stripped from the walls, the joists set on fire, portions of the gas piping were melted, and the meter entirely disconnected. On Monday last, during a thunderstorm at Horndon-on-the-Hill (Essex), a lad, while at work in a pea-field, was struck by lightning and killed. On the same day, 47 sheep were killed by lightning at Overton, near Marlborough, and others were injured. In various parts of the country hay ricks have been fired, houses struck, and cattle killed.

Electric Lighthouses.—Some complaints regarding the electric light at sea have been made to the Trinity House by the Shipmasters' Society. The secretary (Lieutenant Froud) informs the Deputy Master and Elder Brethren that members of the Society in active service, passing from the Thames to sea and *vice versâ*, have often represented to the Committee the poorness, sometimes invisibility, of electric lights during certain conditions of hazy atmosphere. Fault is also found with the intense and blinding effects of such lights as those of the South Foreland on vessels near at hand. To remedy the latter of these defects, it is suggested that coloured glass or other media might be used to tone the light; while to prevent the rays being entirely lost in fog or haze the captains recommend that lighthouses, especially where there is a background of land, should send a beam vertically upward.

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Crystal Palace Electrical Exhibition.—We are informed that the Directors of the Crystal Palace, in deference to the wish of the Electrical Trade Section of the London Chamber of Commerce, have finally decided to postpone the opening of the Electrical Exhibition from November, 1891, till January 1, 1892, on which date the exhibition will be formally opened. The following are a few of the gentlemen who have consented to act as an Honorary Council of Advice:—Prof. W. Grylls Adams, Prof. W. E. Ayrton, Mr. H. R. Beeton, Mr. Shelford Bidwell, Major Cardew, Sir Daniel Cooper, Bart., Mr. J. I. Courtenay, Prof. W. Crookes, Mr. W. B. Esson, Mr. S. Z. de Ferranti, Mr. J. E. H. Gordon, Mr. E. Graves, Mr. J. H. Greathead, Mr. R. Hammond, Dr. Hopkinson, Prof. D. E. Hughes, Mr. Gisbert Kapp, Prof. A. B. W. Kennedy, Mr. A. E. Mavor, Mr. W. M. Mordey, Mr. W. H. Preece, Prof. Henry Robinson, Sir David Salomons, Bart, Mr. Alexander Siemens, Prof. W. C. Unwin, and Major-General C. E. Webber.

Exports of Telegraphic Apparatus.—The Board of Trade returns for July show no diminution in the satisfactory expansion of telegraphic wires and apparatus connected therewith, which has been noticeable since the beginning of the current year. The exports for July were exceptionally large, and the aggregate figures for the seven months show an increase on the corresponding large totals of both 1890 and 1889. In the following table we show the value of the exports for the seven months, in comparison with the corresponding figures for the two previous years:—

	1891.	1890.	1889.
First quarter ...	£653,081	£324,670	£431,309
Second quarter..	331,449	397,042	145,147
Six months	984,530	721,712	576,456
July	150,754	56,575	32,909
Seven months...	1,135,284	778,287	609,365

Patent Litigation in America.—In 1888, the Gaulard and Gibbs patent, held by the Westinghouse Company, was invalidated, and since then that Company has refrained from offensive warfare. An action has, however, now been brought against a local electric lighting company, in Vermont, by the Westinghouse Company, on the strength of Mr. Rankin Kennedy's English patent of 1883, which it owns. This patent claims "the method of distributing and regulating alternating electric currents by secondary generators, which consists in producing in two or more derived circuits constituting the primaries of two or more secondary generators a counter electromotive force which, when any secondary is open, is practically equal to the applied electromotive force in its primary and in controlling said electromotive force by the current flowing in the corresponding secondary when the secondary is closed in such a manner that the current in the primary shall vary with, and be approximately inversely proportional to, the resistance in the secondary, substantially as described."

Search Lights in the Naval Manœuvres.—Many years' experience of search lights in naval sham fights, says *The Times* correspondent convinces me that these machines, which, in certain circumstances are invaluable, are too often so utilised as to be of far more assistance to the attack than to the defence. When an ironclad, believing that torpedo boats are near her, but seeing none of them, begins flashing her search lights in order to discover the enemy, she greatly helps her foe, who thenceforward knows exactly where and how she lies, and to what quarter her uneasy suspicions are directed. By all means cover the mouth of your anchorage with permanent and steady beams of light, so that any craft entering must cross the beams and so reveal herself; but do not let these beams proceed from battleships, or, indeed, from big ships of any sort. They should be thrown only from small craft and from boats, or, still better, from points on shore. The only time, in my humble opinion, when a threatened battleship should use her light is when she has already clearly discovered an approaching enemy. Then let her flash it full into his eyes. It will blind and puzzle him, and, falling on his hull, guns, and paintwork, it will give her a capital target for gunfire. Splendid, when thus used, was the effect of the light upon torpedo boat No. 25, in Luce Bay, on the morning of July 27th. From the moment when the beam struck the boat she was as good as destroyed, for she stood out so clearly that only very bad gunners could have missed her. The light ought not to be worked from any point very near the guns which are to be fired. The ideal position is as far as possible below them. It is, all things considered, a mistake to mount lights on bridges and chart-houses; they cannot be too close to the surface of the water.

Electrical Development in the Sandwich Islands.—The streets of Honolulu, says Mr. J. Cassidy, in a recent issue of the *Electrical Engineer* of New York, are lighted by 92 arc lights of 2,000 c.p. of the Thomson-Houston system, and the dynamos are driven by water-power. The same station furnishes 800 incandescent lights for residences and stores. This plant is the property of the Hawaiian Government. The Queen's Palace has a private plant of one Armington and Sims engine and two Thomson-Houston low-tension dynamos, with a capacity of 600 lights. The Honolulu Iron Works have a plant of 75 lights, operated by a Mather incandescent dynamo. The Union Iron Works have an Edison plant of 75 lights. This enterprising concern have a Thomson-Houston motor in their pattern shop, and have now ordered a welding machine. The telephone industry is also in good condition. Honolulu itself has a population of 22,000, and a telephone system of 1,200 subscribers. On the island of Hawaii there are two telephone companies—the Hawaii Telephone Company and the Hilo Telephone Company. The Maui Telephone Company is on the island of Maui, and the Kaui Telephone Company is on the island of Kaui. The telephones in use are from the American Bell Telephone Company, of Boston. The large plantations have also extensive private telephone service of their own. All telephone instruments and material are free of duty when entered by the Company itself, giving the Company an advantage over the merchants in the importation of electrical goods. Copper wire is extensively used in the construction of telephone lines, because of the salt air. A No. 12 iron wire circuit, nine miles long, has been known to fall to pieces in less than two years, owing to the chemical action of salt water spraying on the galvanised iron. There is also a general use of the telegraph in the island, and one hears a great deal about submarine cables between the Sandwich Islands and the American Continent. The great need of the kingdom is inter-island cable communication.

Edison's Counsel.—The examination of Mr. Edison in the recent lamp patent case gave rise to some statements on his part worth recording, and the speech of his counsel, Mr. Grosvenor Lowrey, was equally fruitful. "Sir William Thomson," remarked Mr. Lowrey, "that great authority, that really wise man, the sort of man who probably did not understand Ohm's law; who, if you had asked him, would probably have said he once thought he did, but was finding out so much every day he was not sure now, had said: 'It is quite possible that a plan of using electrical energy for light may yet be found, in which ten feebler lights will give a sum equal to that obtainable by the same energy in one concentrated light.' . . . . It had not occurred to Sir William Thomson that there were several ways of getting around a stump; that way had to be found out from this practical fellow at Menlo Park, who was so ignorant. He (Mr. Lowrey) had often thought what an awful thing it would have been for the world if Thomas A. Edison had the misfortune to be educated at Stevens Institute. Then he would have known, as they all knew, the mathematics, and then he would have known, too, what things could not be done. There was reason to be grateful that it was not everybody to whom the fortune of a liberal education came, because in this business of investigating nature a liberal education often enslaved the mind. There was Prof. Elihu Thomson; he understood him to be of the opinion that it had been a mere matter of electrical engineering to make this lamp; all the required laws were known, and the rest was mere ciphering. Now, Prof. Thomson was an expert cipherer; he was a professor in Pennsylvania; an inventor; a man of excellent ability. He had been engaged in the search after a small light before Edison began, but it had never once occurred to him to sum up all these outstanding unused laws, which he knew so much about, and evolve the light before us."

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MAGNETISM IN IRON AND OTHER METALS.*—XLVII.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 380.*)

§ 165. **Experiments with Rough Joints.**—Others of the experiments dealt with bars which were simply cut in the lathe, without having the cut ends afterwards scraped to the form of true planes. Joints of this kind, which may by comparison be called rough, were found to offer rather more, but not very much more, resistance than a carefully faced joint, so long as the cut bar was tested without compression. But under compression the difference between a rough and a smooth joint became very manifest; the resistance of the rough joint was comparatively little reduced, and altogether refused to disappear even under the most intense stress.

Table XXVIII. shows the effect of successive cuttings in an iron bar, the joints being in every case of this comparatively rough kind. The bar was tested first in the uncut state, then when cut in two parts, then in four parts, and finally in eight parts, the ends being put in contact without compression.

Table XXVIII.—*Effect of Successive Cuttings.*

Magnetising force due to solenoid.	Magnetic Induction B.			
	Solid bar.	Bar cut in two.	Bar cut in four.	Bar cut in eight.
7·5	8,500	6,900	4,800	2,600
10	11,000	9,000	6,400	3,770
15	13,400	11,550	8,900	5,550
20	14,400	13,000	10,750	7,150
30	15,350	14,550	12,940	9,800
50	16,400	15,950	15,000	13,300
70	17,100	16,840	16,120	15,220

The results of this experiment are also exhibited in Fig. 135, where the full lines show the relation of B to the magnetising force of the solenoid when the bar was in one, two, four and eight pieces. The dotted lines in the same figures refer to a further experiment, in which a compressive stress of 226 kilos. per square cm. was applied, first to the uncut bar, and then to the bar cut in eight pieces.

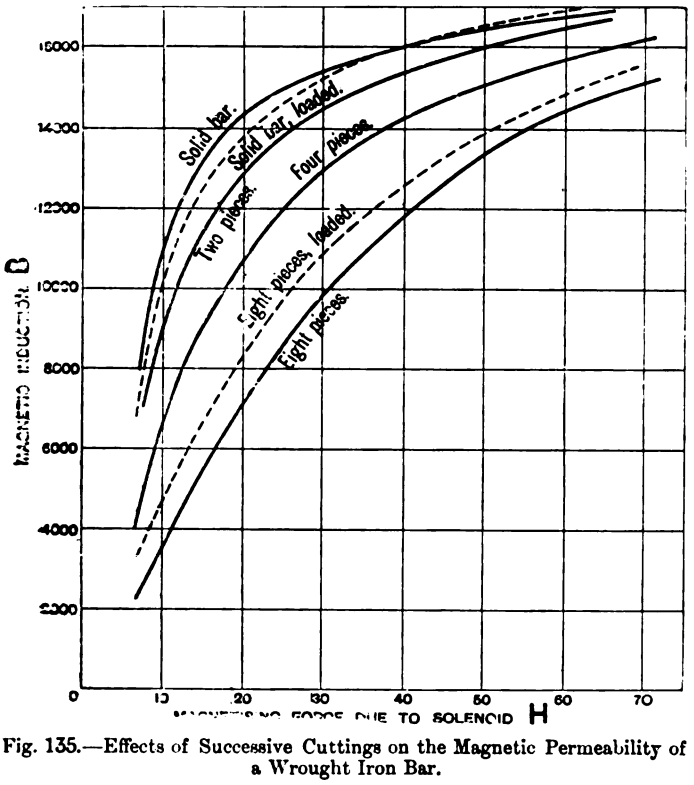

Fig. 135.—Effects of Successive Cuttings on the Magnetic Permeability of a Wrought Iron Bar.

No load .....

Load of 226 kilogs. per sq. centim. -

Comparing the curves for the uncut bar with and without compression, we see that compressive stress lowers the permeability, except when the magnetisation is strong. In strong fields the dotted curve crosses above the plain curve. This gives incidental evidence of the existence of a reversal of the effect of compressive stress, corresponding to the "Villari" reversal of the effect of the tensile stress (see §§ 120, 124-126)—a result to be anticipated from what we know of the behaviour of iron under tension. For values of B below 16,000, however, compression increases the resistance of the circuit so long as the bar is uncut. But when applied to the eight pieces, compression decidedly reduces the resistance of the circuit, even when the magnetisation is weak: the dotted curve for the bar cut in eight lies considerably above the plane curve. In other words, compression lowers, though it by no means destroys, the resistance of the joints, and when the joints are as numerous as they are here, its (positive) effect on them more than neutralises its (negative) effect on the permeability of the metal itself. When the same test was applied to the bar in four pieces it was found the two effects of compression came near to neutralising each other.

In the following table the width of the air-gap which would give the same resistance as the mean of the seven joints has been calculated by the method described above. The results are stated for both cases—with compression and without compression.

Table XXIX.—*Width of air-gap equivalent in resistance to the mean of seven joints.*

B.	Without compression.	With compression of 226 kilos. per sq. cm.
	cms.	cms.
8,000	0·0036	0·0024
10,000	0·0041	0·0031
12,000	0·0046	0·0036
14,000	0·0050	0·0041
15,000	0·0052	0·0041

It appears then that, in round numbers, the resistance of each rough joint was nearly the same as that of a film of air 0·005 cm. thick where there was no compression, and that this equivalent film was only reduced to about 0·004cm. when a compressive stress was applied which would have been intense enough to practically destroy the resistance of the joint had the surfaces been carefully faced. We have seen that a joint with faced surfaces, tested without compression, is equivalent to a film of air about 0·003cm. thick. The thickness of the equivalent film in these rough joints seems to increase a little as the condition of saturation is approached. In the absence of compression a smooth joint is not very greatly better than a rough one. But compression is incompetent to produce, in a rough joint, that extreme closeness of contact which it apparently produces in a smooth joint, in consequence of which the resistance of the smooth joint almost vanishes.

(*To be continued.*)

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ROUGH IDEAS OF THE MECHANISM OF THE ELECTRIC CIRCUIT.

BY S. TOLVER PRESTON.

Why do we want a circuit at all for the electric current? Why does it appear like a *current*? Why is the so-called "current" uniform everywhere, in spite of the varying resistance of the diverse parts of the circuit? These are questions which present themselves repeatedly at this period of transformation of the science, and thought may afford at least a qualitative answer.

Having, in 1875, in a work, "Physics of the Ether," Appendix, p. 133, arrived at some of the main facts now recognised to be true in regard to the ether action in electric effects, there may be some ground for confidence in developing this further now, and attention is invited to a *radial* (or axial) form of vibration, which would seem to have a most practical bearing on the subject—which is undoubtedly a branch of mechanics.

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Consider a circuit. Why is a circuit required at all?—or, rather, why *only* under this condition are the magnetic waves (from which the uniformity of the "current" everywhere is inferred) uniform in intensity everywhere? Obviously, surely, because these waves can only abut against themselves, and so adjust their intensity to uniformity, in a complete circuit. If the waves had anything else but themselves to abut or react against; if they were reflected from masses, for instance, the waves, which are certainly (partly) progressive or "dynamical," would cease to be such, and become entirely stationary (or "statical") by reflection. They would cease (if a closed circuit were wanting) to be waves of that character, which are sufficiently stationary to self-adjust their equilibrium to uniformity, and sufficiently progressive to carry the ether impulses from the pile or dynamo, and supply energy to the circuit at the various points where it is absorbed.

Let us consider an arc light. Carbon "absorbs" these waves more than copper; *i.e.*, its molecules take up the motion of the waves more easily. This is parallel to the absorption of light or radiant heat; which waves are now proved to be the same in kind as electric or magnetic waves. We may figure to ourselves these waves as discs, or rather segments, "threaded," so to speak, on the wire (or, take it, *circular* formed circuit), going off to nothing at the centre of the circuit, and in equilibrium of (oscillatory) pressure among each other, like the "voussoirs" of an arch; also meeting at the geometrical centre* of the circuit. [This is, roughly, the known form of distribution of the "magnetic lines."] The wave segments (or, roughly speaking, discs) of ether oscillate, of course, too axially, *i.e.*, radially† from, and radially towards, the wire; as you cannot press an elastic disc of any kind (or vary the pressure) without making it bulge and contract radially. This fact, as a broad conclusion, may be deduced without difficulty; for it is obvious that two elastic masses cannot come into collision or pressure without radial bulging. [Take an india-rubber buffer, for instance.] That this alternately varying lateral pressure exists in the segments into which the ether of the circuit is broken up, we know for a certainty; for otherwise (obviously) no self-adjustment of equilibrium among the waves or pulses would be possible, which we are sure does occur. Well, of course, this ring-like grip alternately varying in intensity of the ether about the wire, as the radial vibration goes on which accompanies the (abutting) longitudinal oscillation ‡ of the ether segments, or voussoirs in partial stationary vibration (often defined by drawing the "magnetic" lines round the wire)—we see, I repeat, that this partial rush of ether radially out from the wire and alternate rush in at each vibration of each segment, heats the wire or circuit more or less, according as the molecules can more or less take up the motion. There is no vagueness here; for such a movement of the ether is exactly calculated to heat the wire (which it penetrates), as any mechanical mind will see. How is the vibratory movement controlled radially (or rendered stable), it may be said? Why, obviously as the air resonance in an open pipe (is controlled) by producing a *rarefaction* at the centre of the movement So a rarefaction of the ether at the axis of the wire, all along it (and it is a complete circuit without end) is produced; and so the wire forms the axis of* radial vibration.

Now, carbons (of an arc) can take up the motion easily, and so are intensely "heated," as we term it. Of course, the "heating" of the carbons, and consequent loss of energy by the electric or magnetic waves in the act of achieving this, weakens the pressure or energy of the magnetic oscillations where the arc is, or would do so considerably if the adjacent waves (which abut) did not come to the rescue, and give up by simple exchange of motion their energy (unimpaired) to the partially exhausted waves. So a wave disturbance rolls round the circuit, or the arc "draws" energy† to itself in this way, and it soon reaches the dynamo, which at every revolution adds fresh magnetic waves or impulses to the equilibriated ring of them we call the circuit. The waves supplied by the dynamo inevitably adjust their equilibrium of oscillatory pressures by imparting some energy to the adjacent "voussoirs" of the ether arch or complete ring, which is always in stationary and partly *progressive* vibration, which latter indicates the constant supply and absorption of wave impulses in the diverse work done.

Now, why does‡ the arc (or it might be motor) "drain" the energy in this way to itself?—or, rather, this question may now be regarded as superfluous, or a repetition. It simply absorbs more motion; the oscillatory pressure always attendant on stationary vibration (or resonance) then falls, and is supplied or renewed by the oscillating ether segments which are adjacent; and in this way they keep their equilibrium, characteristic of a circuit, and only possible in a circuit. So far without mathematical development, we may grasp at broad facts, which will doubtless be seen by all ultimately with physical powers of imagination.

In the electric light, we may figure to ourselves, then, wave motion of a long dimension *approaching* the carbons (in the main radially) and *receding* from the carbons after having been converted into *shorter* waves. The whole circuit is in pressure of electric oscillating waves, which tend to "burst" it outwards, as it were. This fact we express by saying that the "current" repels each opposite part of itself and each adjacent part of itself. It is simply the repulsion attendant on that "resonance" which we know accompanies electric effects, and which in a circuit exercises a bursting tendency. Inferentially the whole is restrained (as any form of resonance) by a rarefaction at the§ centre of all.

The wire has been described as the "sink" where the energy is wasted. In fact, the wire produces a radial progressive oscillation of the ether all about itself, as it continually absorbs, more or less, the resonant energy vibrating through its substance, which is soon made good by the dynamo, which is a mere wave-emitter introduced into the circuit, and keeping up the wave supply.

After the circuit has been fairly closed, and the equilibriated wave system (stationary and progressive) thus established, there is nothing like a "current" along the wire; but a

* This is only true, in strictness, when the circuit is uniformly circular in form.

† This form of radial (or axial) vibration was first pointed out by me in an article in *Engineering* for March 17, 1876. The significance of this form of *radial* vibration of an elastic medium does not seem to have been adequately appreciated; and one object of the present Paper is to treat of it in relation to the electric circuit. This kind of vibration (a unique condition for stability) would seem from its character to have numerous practical applications in nature; and in a future Paper I may consider some of its bearings on acoustics—air "resonance." The theory or sketch of the mechanics of the electric circuit here offered does not, of course, profess to be more than an outline or sketch—a kind of stop-gap. To say one word more about radial or axial vibration. The cylindrical air column, for instance, intercepted between two opposed metal discs, may be made to vibrate as stably as the air column in an open pipe, provided the air vibrates in such a way that all its parts move outwards from the axis joining the centres of the two opposed discs, at the same instant, and (conversely) recoil inwards simultaneously towards the axis at the backward stroke or swing. The rarefaction at the axis of the cylindrical air column makes the column recoil backwards sideways between the discs as if it were connected by radial elastic bands. Analogous considerations seem also possibly applicable to the free column of ether intercepted between two opposed vibrating molecules; indeed, the application seems difficult to limit, since no two bodies (large or small) can vibrate without intercepting a free column of the medium between them, which is open to vibrate radially.

‡ This *radial* vibration seems the *only* form that can ensure stability even approximately. Combined with the longitudinal oscillation of the segments, they form two mutually supported movements *transverse* to each other (much in correlation with the electrostatic and electro-magnetic states). Of course, we assume the ether to be to some extent compressible, and there is no real objection to this.

* No pipe actually is required here, of course, because the ether moves radially outwards (from the axis of the wire) all round the wire, *at once* or at the same instant, and so there is a balanced equilibrium of elasticity. This is doubtless one reason why *a circuit* is required for the conditions of dynamical equilibrium. Such a wave movement can conceivably extend in segmental form beyond the surface of the wire, and even to the centre of the circuit, where the waves would be reflected from each other, or all impinge together at the central point of the system.

† This special capacity of stationary vibration to draw energy to itself might be simply illustrated by imagining a line of perfectly elastic spheres in mutual collision, all the odd spheres moving simultaneously in one direction, while all the even spheres move simultaneously in the opposite direction. If, now, the end sphere be allowed to do external work by imparting motion to something, a wave will immediately run along the line of spheres, indicating the supply of energy furnished by the end spheres—equilibrium being in this way automatically restored or brought about. The end sphere (next where the work is done) thus "draws" a supply of energy to itself.

‡ A "resistance" of any kind may be regarded as a means or adaptation for communicating motion—either small scale motion ("heat") or large scale motion, commonly called mechanical motion.

§ The position of this controlling rarefaction, which forms a sort of dynamical centre of gravity, would depend, doubtless, somewhat on the position of the absorbing points (arcs, motors, &c.) in the circuit.

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wave movement absorbed sideways into the wire all round,* which continues as long as the circuit is closed, of course. The chief purpose of the wire (circuit) is apparently to produce and maintain an equilibriated system of (wave) energy in the ether, which is the absolutely necessary preliminary for the constant supply of energy, the energy then choosing its own route, according to mere equilibrium of pressure of the system —in part going along the line of the circuit, and in part doubtless across, according to the position of the absorbing points for the energy (arcs, motors, &c.). The waves or impulses must evidently be more or less statical or stationary in order to constantly supply energy laterally to the wire and absorbing points (for mechanical work) in the circuit, and stationary waves imply necessarily an equilibriated system. The "current," or (more correctly speaking) wave motion enters the wire, then. in the same direction as the radiation of wasted heat leaves it. It is a mere case of the transformation of long waves into short waves—"radiant heat." Energy is said to flow along "equipotential" lines. This seems to be because a line of energy transfer (or supply) is in general a line of ether in stationary vibration. We see that it is a characteristic of stationary vibration that the pressure should be the same throughout the line (indeed, this is a self-righting adjustment). Hence it seems that a line of energy transfer must (under these conditions) abut or end at points of equipotential, *i.e.*, points of equal pressure. The flow of energy would be initiated by incipient differences of pressure, doubtless too small to be measurable, as the supply of energy is so rapid. A belt transmitting 7,000 H.P. at the velocity of light would be only under a stress of 26 to 27 grains, as may be computed. Hence the ether is a mechanism adapted for transmitting considerable quantities of energy† with very small stresses accompanying the carrying over of the energy.

We may venture here a speculative idea in relation to the electric light. In an arc light there is an ether rarefaction at the axis, about which the ether vibrates radially all round. No other vibration is possible, or even approximately stable, apparently. When the carbons are removed too far apart the arc snaps by the filling-in of the ether rarefaction, and, the equilibrium of the circuit being thus upset, the whole balanced wave system collapses (ceasing to be a circuit). At the same time the collective momentum (impulses) of the progressive waves, which tend to continue their career and bridge the interval, may constitute the induction "current" on breaking the circuit.

The sketch or mechanical outline thus offered wants filling-in as to certain points, no doubt. The hydraulic analogy, however ingeniously defended, cannot be said to hold its gronnd, and a provisional stop-gap elementarily evolved and capable of being followed easily, may be found of service, even although it does not profess to be complete, or even exact in detail. Hence‡ the above Paper.

* This lateral absorption of magnetic waves into the wire (attended by production of heat) is uniform, as we know, everywhere, no consequence how far the wire extends from the source; and this doubtless leads to the idea that it is a "current" or something flowing equally through the wire. But the apparent cause of this uniformity of absorption is the uniformity along the circuit of the magnetic waves themselves, which oscillate about the wire as an axis; and the uniformity of these waves is self-righting, as must be the case with every (more or less) stationary vibration.

† May not the polarised wave motion, or the (seemingly) molecular effect we regard as such, be something supplementary which does not substantially influence the equilibrium of the ether *en masse*?

‡ What significance has Ohm's law, it may be asked, in view of the new ideas? The law seems to apply still to transfer of energy, instead of to (as incorrectly assumed) longitudinal transfer of something called "current," along the substance of the wire. We have to regard "electricity," it would appear, as a form of energy to which the principle of equivalent convertibility, applies as to other kinds of energy. Whether the form of pulsatory wave movement about the circuit, as above gone into, would not tend to dissipate itself somewhat in the ether (in spite of the central reflection), may be a question; but it is one which does not materially affect the broad mechanical principles of the circuit and its purpose we have been considering. If the exact nature of ether waves of all kinds be in the end known, even in its minutest details, this will not apparently influence he elucidation of the object fulfilled by the circuit, and as to how it allows us to utilise the ether as a power transmitter, which is the practical point with which we are concerned. It appears, so far, a safe conclusion that radial or axial vibration is an important element in "resonance," whether of air or of ether. An assumed entirely inelastic ether is, in our view, unintelligible as regards wave effects or equilibrium at all, and we do not suppose such an idea is seriously supported.

PRIORITY IN ROTARY CURRENT MOTORS.

The following communication of Prof. A. du Bois-Reymond to the *Electrical World* of New York, of August 1st, will be read with interest:—

"With a feeling of lively satisfaction I note that you have seen fit to reproduce my Paper on rotary current in No. 26, Vol. XVII., of your esteemed journal, and I consider myself greatly flattered by the kind words of recommendation with which, in your leaderette, you invite your readers to peruse my work. But, on the other hand, I cannot help taking the liberty to state that I consider your criticism of my way of treating the priority question as unjust. I dare say you are aware that the question of who deserves the credit of being the only original inventor of electro-magnetic rotation is at present being ventilated with great ardour among the technical public all over Europe. I have followed all publications on this important subject from the beginning with great interest, though personally I have had no share whatever in the really original work done up to date. I therefore feel justified in considering myself as an outsider who can lay claim to the ability of forming an unbiassed opinion.

"Now, I personally hold that disputes on priority as far as they do not purely relate to the business side of the question only tend to pervert the historical truth. If A and B nearly simultaneously discover a new truth, why is A to be more honoured by mankind than B because he conceived his first glimmering of the new idea while walking to his office on the morning of the nth, while B only hit upon the same line of thought while smoking at his fireside after dinner of the $(n+i)$ th? We ought simply to state what A did, and what B did, and to erect statues to both in their respective native villages. But if it comes to using their names as technical terms for the new invention, one must decide which to use, and in that case I think there is no other possibility than to find out who was the first to publish, patent, or otherwise make known to reliable witnesses, if not the public at large, his new idea. May be Mr. Tesla was in the field every bit as early as Prof. Ferraris, but by some chance or other which may be and most likely is neither the fault nor the merit of either, considering that there were at the time a few thousand miles of land and sea between them, Prof. Ferraris published about six weeks before Mr. Tesla. Moreover, Prof. Ferraris published a treatise exposing theoretically nearly all the principles underlying the new system, while Mr. Tesla published a Paper mainly describing a more or less practical motor founded on the same principles, and only gave a short exposition of a part of the said principles to make his meaning clearer to his audience. Therefore, according to the accepted rule of such formalities I consider myself justified in talking of the "Ferraris principle" and of the "Tesla motor," because everybody who is acquainted with the scientific etiquette knows perfectly well that by this mode of expression I do not offer incense to the one and contempt to the other, but simply mean that according to my knowledge of history the one has been the first to *publish* the principles and the other the first to patent the motor. You might contend that in order to construct a motor a man must be master of its principles and not *vice versâ*; therefore Mr. Tesla by publicly describing his motor has proved that he possessed the principles before Prof. Ferraris' publication. This I will freely admit, though such a contention is certainly open to controversy; but then that would only be one reason more to hold up Prof. Ferraris' merit beside Mr. Tesla's, because even the most ferocious Teslaite must allow that there is merit worth mentioning in having published the said principles. Now, by talking of the Tesla motor we do not detract in the least from Mr. Tesla's merit, because, having constructed his motor, everybody will credit him with understanding the underlying principles, and everybody who is acquainted with the chronology of the case will easily infer that he must have evolved those principles without the help of Prof. Ferraris' publication, which could hardly have reached him before he filed his first patent. On the other hand, if we would neglect to mention Prof. Ferraris as the first pub-

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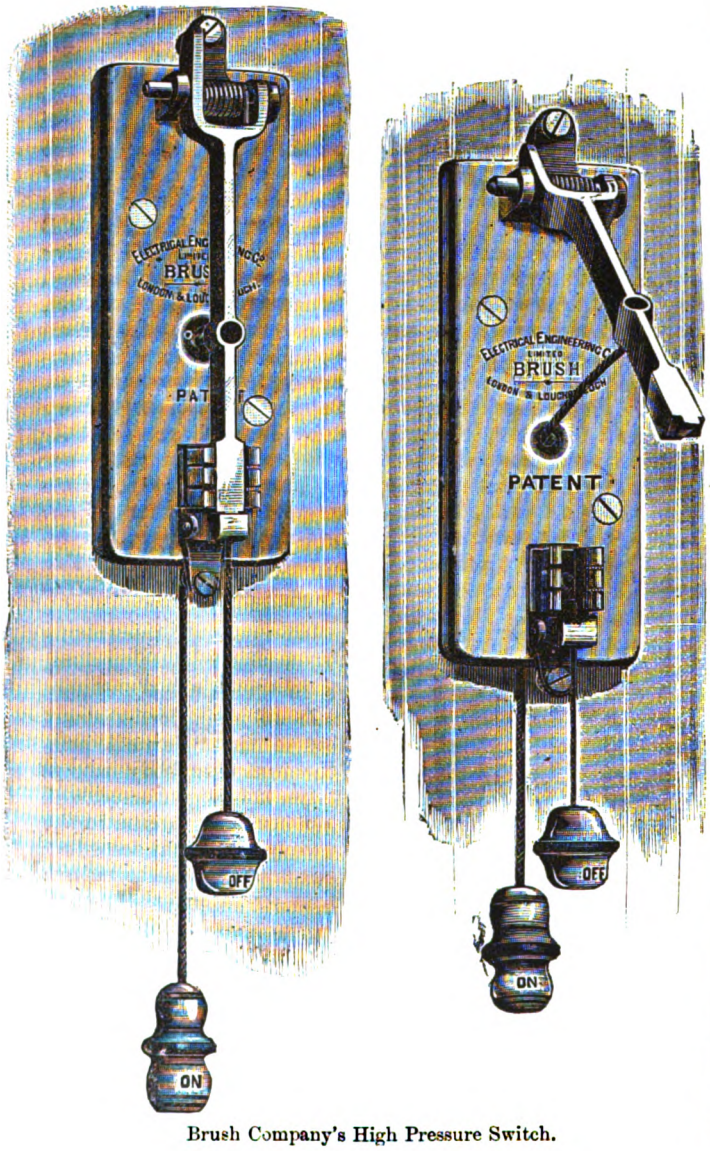
lisher of the said principles, we would ignore his merit altogether.

I must apologise for having suffered myself to be drawn out to such a length by your casual remark, but, considering the great interest brought forward *in re* priority of electromagnetic rotation in this country, I hope I may find indulgence.

THE BRUSH COMPANY'S HIGH PRESSURE SWITCH.

In the numerous switches which are now offered for use with high pressure circuits, the safety of the operator is generally provided for by long and well insulated handles. Sometimes a cover is relied upon to keep his hands away from the bare metal, and a kind of kilt has been added in other cases to guard against an accidental slip of the hand. At Deptford, and on other parts of the circuits of that station, Brobdignagian "jack-knives" are employed, while the Thomson-Houston Company use a loose handle and a spring catch, which bears no resemblance to a switch.



Brush Company's High Pressure Switch.

The Brush Company have for some time been using a switch which has much to recommend it, not the least important feature being the perfect safety from accidental contact with the switch itself. As all switches ought to be, this one is constructed entirely of porcelain and metal. The two illustrations show very clearly the action of the parts. A lever is hinged with a good wide hinge, allowing no side shake, and wh ch is provided with a strong spiral spring tending to open the circuit. The lever can be pulled down by a stout cord, to which is attached a porcelain knob, marked *on*. When this is pulled down as far as it will go, the lever is jammed between two spring contacts, and is caught by a spring "trigger." The release is simply effected by means of another cord with a porcelain knob, marked *off*, and this pulls back the trigger and allows the spiral spring to throw up the lever, making a long and a quick break. There is some prejudice against the use of springs, and this has no doubt arisen from the use of poor material in cheap switches, and from bad designing, a common fault being that the spring acts in a very indirect manner and with considerable friction. For the moderate currents commonly used in alternate current work this switch appears to be excellently adapted. There is no necessity for the operator's hands to come anywhere near the metal, and the break is bound to be rapid and complete.

THE SWINBURNE NON-INDUCTIVE WATTMETER.

Messrs. Swinburne and Co. have recently brought out a wattmeter designed to avoid the errors due to the appreciable time constant usually possessed by the fine-wire circuit of such instruments. The moving coil contains but few turns, and these are wound on a light mica former. The coil is held by top and bottom stretched wires. External resistances are supplied, wound with the alternate layers right and left handed, so that the time-constant of the fine-wire circuit is made sensibly equal to zero. Readings are taken by means of a torsion head in the usual way; but for measurements of

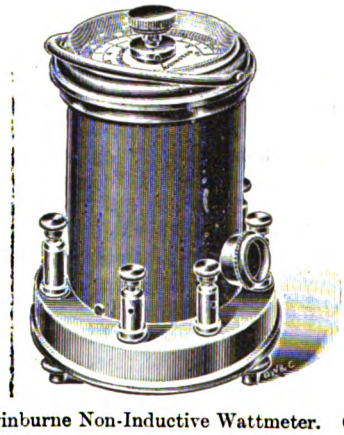


Fig. 1.—Swinburne Non-Inductive Wattmeter. General View.

minute powers, such as hundredths of a watt, a mirror is used. These wattmeters are wound to suit any range from 3,000 volts and from 25 amperes downwards. The makers claim that they read accurately on non-inductive resistances, and on inductive circuits in which the product of the pressure and current is 50 times the real power.

A general view of the instrument is given in Fig. 1, and the construction of the wattmeter is more clearly shown in Fig. 2. Two cast gun-metal columns carry the fixed coils; one of these coils is removed, showing the cylindrical mica former mounted on an ivory spindle. This spindle passes through top and bottom guides, and the suspension is kept taut by a spring at the bottom. The instrument can be sent about without slackening the suspension, as the coil is very tight, and it cannot move far sideways. The zero index stretches over a mark on a slanting plane. This is visible through a hole in the dial on looking down on the instrument, being lighted by a circular window in the case. A plummet is also arranged for levelling, but is taken off in our illustration to admit of a clearer view. The current coils can be easily changed without interfering with the suspended system. This is important, as one set of coils only suits one range. For instance, a voltmeter or ampere meter for 100 volts, or 100 amperes, is always ready, but a wattmeter for 100 watts may be called on to read with 100 volts and 1 ampere, 100 amperes and 1 volt, or any other pair of factors. The most convenient range for a wattmeter is 100 volts, and any current up to 20 or 30 amperes. It is then available for measuring transformer efficiencies by measuring

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the power going in on the 100 volt side, when the transformer is used to transform up at no load. To measure the primary power needs a resistance of some 80,000 ohms in the 2,000 volt circuit, and this means 40 watts, or 80, which must be allowed for if the instrument is coupled up, so that the fine wire current also flows in the current coils.

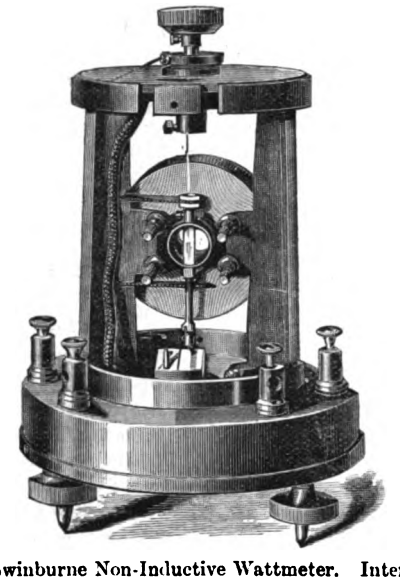
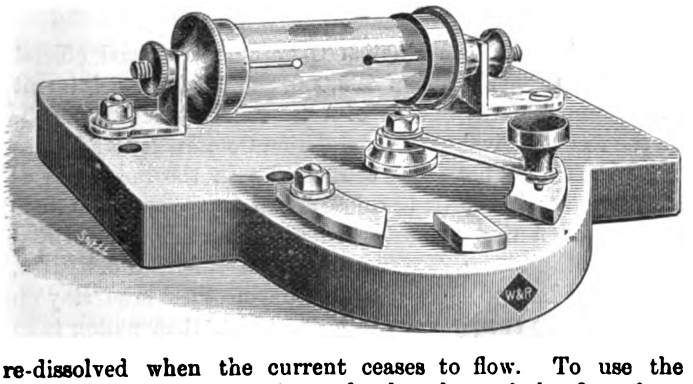


FIG. 2.—Swinburne Non-Inductive Wattmeter. Interior View.

Mr. Swinburne recently described an electrometer which reads power directly, which, though it does the work of the three voltmeters discussed by Messrs. Ayrton, Sumpner, and Swinburne soon after, unfortunately needs resistances. Dr. Fleming has enormously improved the three-instrument method by substituting ampere meters, and we thus have unassailable means of verifying the wattmeter.

WOODHOUSE AND RAWSON EARTH DETECTOR.

Our illustration shows an instrument designed with a view of placing in the hands of householders and others using the electric light a ready means of detecting any leak or fault which may develop itself in the insulation of the installation. On a polished slate base is mounted a small glass tube, one end of which is connected to some good earth, while the other may be connected at will through a switch with either lead. The tube is filled with a liquid which is decomposed when a current is passed through it, the positive electrode becoming covered with a reddish brown deposit, which is slowly



re-dissolved when the current ceases to flow. To use the instrument, connection is made by the switch, first from earth to one lead of the installation, and then from earth to the other. If the insulation of either lead has become defective, it will be shown by the discoloration produced. This instrument is not intended as a substitute to the electrician for quantitative measurements, but it may be found useful in ascertaining, from time to time, in a simple manner, whether the insulation of house circuits is in a perfect condition or not. The detector is manufactured by Messrs. Woodhouse and Rawson.

INSTITUTION OF ELECTRICAL ENGINEERS.

At a special general meeting of members only of the Institution of Electrical Engineers, held yesterday, at the offices of the Institution, the subjoined resolution was unanimously passed:—

RESOLUTION.

"That Nos. 22, 23, 25, 26, and 27 of the Articles of Association be altered so as to read as follows:—

Article 22. "Every Member elected before the 31st of December, 1891, shall pay to the Institution an entrance fee of Two Guineas on his election; or, if elected after the said date, an entrance fee of Three Pounds. Every Foreign Member shall pay an entrance fee of One Guinea. Every Associate, if elected before the 31st of December, 1891, shall pay an entrance fee of One Guinea; or, if elected after the said date, One Pound Ten Shillings. Every Associate transferred to the Class of Members before the 31st of December, 1891, shall pay a further entrance fee of One Guinea; or, if transferred after the said date, a further entranee fee of One Pound Ten Shillings. Every Student transferred to the Class of Associates shall pay an entrance fee of One Guinea."

Article 23. "Except as hereinafter provided, every Member elected before the 31st December, 1891, shall contribute annually to the Institution the sum of Two Guineas; or, if elected after the said date, the sum of Three Pounds. Every Associate elected before the 31st December, 1891, shall contribute annually the sum of One Guinea; or, if elected after the said date, the sum of One Pound Ten Shillings. Every Foreign Member shall contribute annually the sum of One Pound, and every Student Half a Guinea. Any Member or Associate residing abroad, or absent from the United Kingdom for nine months in any year, and giving previous notice in writing to the Secretary of his intended absence, shall contribute annually the sum of One Pound."

Article 25. "Any member elected before the 31st December, 1891, may compound for his annual subscription by the payment to the Institution in one sum of Twenty-one Pounds if resident in the United Kingdom, or, if resident abroad, by the payment in one sum of Ten Pounds. Any Member elected after the said date may compound by the payment in one sum of Twenty-five Pounds if resident in the United Kingdom, or, if resident abroad, by the payment in one sum of Ten Pounds. Any Associate elected before the 31st December, 1891, may compound for his annual subscription by the payment in one sum of Ten Pounds; or, if elected after the said date, by the payment in one sum of Twelve Pounds Ten Shillings if resident in the United Kingdom, or of Ten Pounds if resident abroad. Any Foreign Member may similarly compound by the payment in one sum of Ten Pounds. Any Foreign Member, or any Member who, as residing abroad, has compounded by payment of Ten Pounds, shall, if he come to reside in the United Kingdom, and if he was elected before the 31st December, 1891, pay either an additional composition of Eleven Pounds or an annual subscription of One Guinea. If he was elected after the said date, he shall pay either an additional composition of Fifteen Pounds or an annual subscription of Two Pounds. Any Associate elected after December 31st, 1891, who, as residing abroad, has compounded by the Payment of Ten Pounds, shall, if he comes to reside in the United Kingdon, pay either an additional composition of Two Pounds Ten Shillings or an annual subscription of Ten Shillings.

"All such compositions shall be invested, and the interest alone shall be appropriated to the current expenditure of the Institution, at the direction of the Council.

"Any donations in aid of the funds of the Institution may be accepted by the Council and Treasurer."

Article 26. "A Foreign Member who has not compounded shall, if he come to reside in the United Kingdom, pay an annual subscription of Two Guineas if he was elected before the 31st December, 1891, or of Three Pounds if he was elected after the said date."

Article 27. "An Associate resident in the United Kingdom who has compounded by payment of Ten Pounds shall, if transferred to the class of Members before the 31st December, 1891, pay either an additional composition of Eleven Pounds or an annual subscription of One Guinea. If transferred after the said date, he shall pay either an additional composition of Fifteen Pounds or an annual subscription of Two Pounds. An Associate resident in the United Kingdom who has not compounded shall, if transferred to the class of Members before the 31st December, 1891, pay an annual subscription of Two Guineas; or, if transferred after the said date, an annual subscription of Three Pounds."

BOOKS, &c., RECEIVED.

"Primary Batteries." By Henry S. Carhart. (Boston: Allyn and Bacon.)

"Die Fortenwicklung der Elektrischen Eisenhahn-Einrichtungen." By L. Kohlfürst. (Vienna: A. Hartleben.)

"Transactions of the Royal Society of Edinburgh." Vol. XXXIV. Vol. XXXVI., Part 1. (Edinburgh: Robert Grant and Son.)

"Proceedings of the Royal Society of Edinburgh." Vol. XVIII., pp. 65-260. (Edinburgh: Robert Grant and Son.)

"Electric Transmission Handbook." By F. B. Badt. (Chicago: Electrician Publishing Company.)

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The Electrician.

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THE CHICAGO EXHIBITION.

The decision of the English Government to lend official support by voting a grant of £25,000, and by the appointment of the Council of the Society of Arts as a Royal Commission, and the recent arrival of the Exhibition Commissioners in this country, warn us that those connected with the industries of Great Britain will shortly be called upon to make up their minds whether or not these industries shall be worthily represented in 1893 at the Chicago Exhibition. The American delegates, it must be admitted, have displayed during their brief stay on our shores the energy and push for which their nation is so justly famed. They have indefatigably interviewed and been interviewed, dined and been dined. No one in the remotest degree likely to contribute to the success of the Exhibition, from the Queen, Lord Salisbury, and the Secretary of State for India, down to the Lord Mayor and the London Chamber of Commerce, has escaped their eagle eye; and at the present moment the same process of buttonholing is being vigorously carried out on the Continent. It is needless to say that the delegates have everywhere been cordially greeted, and have received profuse promises of official support. The present

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inhabitants of the United States are proverbially smart, but it must tax this gift somewhat severely to muster up a valid reason either sentimental or based on mere business considerations, why English traders, as a body, should take any enthusiastic interest in the proposed "World's Fair."

The trade of this country with the United States is undoubtedly large, larger indeed than that with any other single country in the world, yet it forms but a small proportion of our trade with the entire world. According to the latest statistics available England's total trade with the world amounts, in round figures, to £864,000,000, of which our trade with the United States forms but £121,000,000, or 14 per cent. A trade of this volume is certainly not a negligible quantity, but, considering its nature, the fixed determination of one of the parties concerned to reduce it to a minimum, and the enormous distance between London and Chicago, it is difficult to see what English commerce, as a whole, has to gain by lavish exhibiting, although particular industries will probably find sufficient incentives to spend money in this direction. And as to sentimental considerations, which indeed come into play but weakly in such matters, they are not very apparent. It is to be doubted whether the quincentary of Columbus's arrival in the West Indies is a sufficiently powerful lever to move Englishmen, with their "inborn conservatism," to despatch goods several thousands of miles across land and water to encounter, on their arrival, the chilly blast of the McKinley tariff. The English Government thought fit to withhold its official support from the Paris Exhibition of 1889, because it celebrated the centary of an event which, although stirring, was one about which there is a wide divergence of opinion. In spite of the absence of official sanction, English exhibitors mustered in force. Their interests lay that way, and Paris was not as many hundreds of miles away as Chicago is thousands. Official support and the efforts of the Royal Commission and the Exhibition Commissioners notwithstanding, we venture to predict that English exhibitors will not be present in full force at Chicago. Three inducements are necessary to ensure their presence—namely, self-interest, proximity, and a spark of enthusiasm; and it is these very desiderata that are conspicuous by their absence.

However convincing the arguments for holding aloof from the 1893 Exhibition may be when applied to the industries of England as a whole, they apply with redoubled force to the electrical industry. While no good Englishman can be got to admit for one moment that American electrical engineers turn out such efficient plant as we do, there is no gainsaying the fact that they turn out considerably more. Until a few years ago the English electrical engineer spent his enforced leisure in bringing dynamo and engine design to a science. Meanwhile across the ocean there was an immediate and large demand; dynamos had to be constructed somehow, and were generally constructed anyhow. Just at the time when we were celebrating the passing of that act of reparation known to lawyers as the Electric Lighting Act (1882) Amendment, our American friends, having solved the problem of electric lighting after their kind, were turning their energies to electric traction, in which branch of applied electricity there seems to be every chance of history repeating itself. The net result is that the Americans have evolved, under the conditions peculiar to them, several systems which meet the exigencies of transatlantic work; and they can now get along very well to their own satisfaction without us. Even if Free Trade prevailed between the two countries we doubt whether the United States would offer a very favourable market to English electrical apparatus, and with a prohibitory tariff in full swing, the attempt to force a market by dint of superior quality is hopeless. In Germany, electric lighting is fairly prosperous and progressive, import duties, though high, are not prohibitive, and German engineers can boast neither of the experience nor of the ingenuity of their American brethren; yet, in spite of the great exertions of the promoters, the title is, perhaps, the most international feature of the Frankfort Exhibition.

Though lacking in "internationality," the Chicago Exhibition will, it may be safely said, prove eminently successful as a big national show. To doubt it would be to indict a whole people, and that we have it on good authority is impossible. With its vast area and population, the diversity of its climate and products, and the ingenuity and energy characteristic of the race, the people of the United States should be able to get together a "fair" which will astonish the world, and in this "fair" no department will be of greater interest than that devoted to electricity. Englishmen will there be able to see the many strange things in electricity that America has brought forth during the past ten years. There will be much to learn, and, perhaps, something to unlearn, and a harvest of knowledge will be reaped in a few hours which, without the Exhibition, would require months of weary journeying in "palace cars." English electrical engineers may well wish success to the Exhibition, though they fail to discover valid reasons for taking part in it.

THE CONTOUR OF SOME COSMICAL VARIATIONS AND THEIR APPARENT TEACHING.

BY ALEX. J. S. ADAMS.

In connection with cosmical science, there is, perhaps, no branch more beset by difficulty than that of the daily variations in the earth's electricity and magnetism due to the ceaseless interactions of separate self-varying forces; nor in its connection is it an easy task to demonstrate to other minds effects which the familiarity of long study may have made clear to one's own.

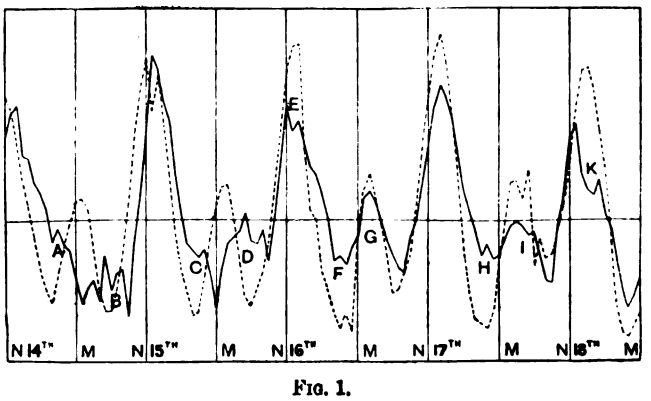

Fig. 1.

——— Declination. ..... Derived.
January, 1884.

In respect of the earth's magnetic and electric variations, the attempt is, however, here made if only that the point of view from which the subject has been studied by ourselves may become plain to other students; and that the subject may obtain greater prominence than it at present enjoys. It is not here proposed to offer an opinion upon the earth's *directive* influence, nor in respect of the *fact* of the declination; we seek only to bring under notice certain features of variation contour, aud to suggest truths which appear to us to underlie them.

Our first example of cosmical variation is given in the diagram (Fig. 1), in the continuous line curve, where we have the daily variation of magnetic declination as found at the Royal Observatory, Greenwich, during the 14th to 18th January, 1884. The letters N and M indicate noon and midnight, and are separated by their intervening hours.

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Now, the first feature we notice about these curves is the similarity of one day with another. In the second place, we observe in each day a following of the sun's movement relative to the horizon, insomuch that whilst the curve is above the mean line during the daytime, it is generally below the mean line during the night hours. Thirdly, we notice that the otherwise smooth curve is frequently broken up, as at A, B, C, &c., especially during the night periods; and consequent upon which there exists a continuous tendency towards a system of daily double change, as instanced at B, D, G and I. In the

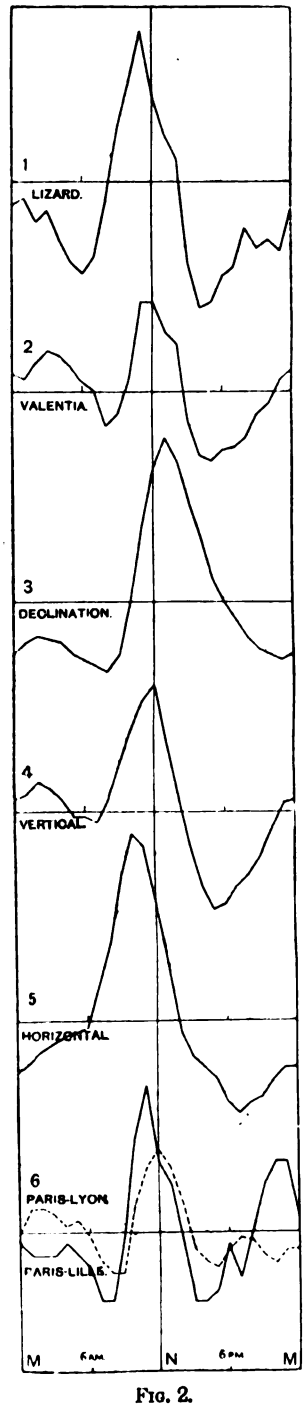

FIG. 2.

fourth place, we notice that superposed upon the general sun-following—or diurnal inequality—there is a peculiar flattening effect during the night periods, as against a marked peaking at noontide. Thus, in respect of the magnetic declination, daily variation, we have these four features:—(1) Daily similarity; (2) Daily sun-following; (3) Double daily change; (4) Noontide peaking.

But we have yet another feature to consider, namely, the possible similarity of daily contour between the variations of the different elements of the magnetic and electric phenomena. In diagram Fig. 2 we present, for comparison, curves of diurnal variation for the various elements, and which are consecutively as follows:—(1) The mean daily earth-current variation for 30 days, as observed at the Lizard Office upon the Lizard-Bilbao cable; length, 480 nauts.* (2) The mean daily variation of 78 days' earth-current change, as observed upon a submarine cable, extending 1,850 nauts, from Valentia into the Atlantic.§ (3) The mean diurnal variation in magnetic declination for every day of the year 1889, as observed at the Royal Observatory, Greenwich.† (4) The same of the magnetic vertical force.† (5) The same of the magnetic horizontal force.† (6) Examples of diurnal earth-current variations, as observed upon the Paris-Lilles subterranean conductor for March 13th, and Paris-Lyon for October 30, 1884.‡

The evidence here afforded of accord between the magnetic and electric daily variations is sufficiently demonstrative of the fact that in each case the four laws already alluded to strictly obtain. Moreover, it is here clear that in analysing the variation of one element, we to a large extent analyse the others.

For the purpose of analysis we select a series of earth-current variations, as observed upon one of the Atlantic cables by Mr. James Graves,§ and we do this because of the large extent of globe-surface embraced by the cable; and because of the sensitiveness of the apparatus used. Examine the example of this Atlantic earth-current variation for March 8, 9, 10, 1871, as shown in diagram Fig. 3 (*dotted* line I) where also N and M represent noon and midnight. The daily sun-following, and the tendency to a diurnal double change, are clearly depicted.

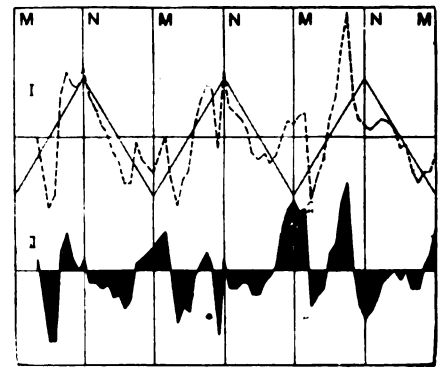

FIG. 3.—Valentia. Diurnal Tides.

The noon peaking is not well developed, but we should not fall into the error of supposing that because this last is inconspicuous the whole variation is necessarily separate and different, because the direction occupied by the electric conductor and the angle at which the magnetic measurements are taken would seem to materially modify the contour of the final result.

Let us more closely question these curves. To do so we draw the ideal solar-inequality line diagonally from N to M, and from M to N, and we then measure the dotted curve from it. The ideal solar line is now brought down and straightened (Fig. 3, II), to form a new *mean*, and the results of our measurements are stated in curve, proportionately above and below it. This new curve—darkened to render the result more conspicuous—distinctly tells us that whereas we had in curve I a diurnal sun-following, distorted in places, we now have in curve II., by the elimination of the inequality effect, a system of self-contained double variation not unlike that of the ocean tides, and thus the distortions to the solar-inequality curve are largely explained.

But in connection with this double motion, we have to ask, "Is it a true tide?" that is to say, "Is it some gravitation effect, and is it of solar or lunar origin?" Both queries may, perhaps, be answered by learning whether this earth current has a periodic movement coinciding with new and full moon; in other words, with the ocean, spring, and neap tides. In diagram, Fig. 4, the total daily variation for each day of 78 days upon

* Kindly placed at our disposal by Sir James Anderson.
† William Ellis, F.R.A.S., *Phil. Mag.*, January, 1891.
‡ "Etude des Courants Telluriques." Par E. E. Blavier. Paris, 1884
§ *Jour.* Soc. Tel. Eng. Vol. II. No. 1, 1873.

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this Atlantic cable is reduced by a constant, and the result thrown into curve. The lines F and N denote the times of full and new moon during the period of observation.

The outcome of our inquiry is most clear in exhibiting a distinct succession of electric spring and neap tides, which certify that the double change shown in curve II. (Fig. 3) is a true tide, and by inference due to the presence of both a solar and a lunar tidal effect.

In respect of this Atlantic cable, therefore, we reach definite ground, namely, that the earth current daily variation is built up of at least three separate forces—a solar-inequality, which we may term T 1, a lunar-diurnal double tide, T 2, and a solar-diurnal double tide, T 3. But we have yet to see how far this building up by the three T's obtains in respect of other earth-current conductors, and the magnetic elements. And, first, in support of the contention that the same law applies to them all, we have the practical similarity of contour exhibited in the curves of Fig. 2, and by which we learn that although the diurnal variation may exhibit an endless variety of modifications, the diurnal "characteristic," as illustrated by the four laws already enunciated lies at the base of them all. And, second, there is the fact—not demonstrated here owing to want of space—that the feature of springs and neaps obtains also in connection with the earth-current records of the Royal Observatory, Greenwich, aerial conductor; with those of a London-Cardiff post office aerial conductor; with those of the Paris-Lille, the Paris-Lyon, and other subterranean conductors; and in respect of the three magnetic elements. These spring and neap effects combat once and for all any idea of causation in submarine cables by the movement of tidal waters. Nevertheless, the spring and neap effects are as much interwoven with other phases as is the diurnal solar-inequality. For instance, there is exhibited—especially in the magnetic vertical force variation—an unmistakable lunar-inequality effect, and careful inquiry will frequently elicit the result of the rolling, one over the other, of the inequality and spring-neap forces. An interaction of this kind is presented to us by a discussion of the Greenwich vertical force variations for April to December, 1884, as illustrated in diagram (Fig. 5). Following the curve of daily variation there shown, we find that the new and full moon periods M and F are clearly *single*, that is to say, are lunar-inequality movements, accompanied by interruptions caused probably by the spring and neap effects K and K. F_2, N_2 are *mixed*, insomuch that little can be made of them; a mixing, by the way, which seems to have periods of recurrence of about three or four months. F_3, N_3, F_4, N_4, are clearly inequality effects, whereas F_5, N_5, F_6, N_6, are spring and neaps. At N_6, N_7, the curve is again mixed, but thence resolves itself into inequality.

We now reach another definite point for consideration, and it is this:—"As T^2 and T^3 are tidal, with daily double motions, may not T^1 be tidal also, notwithstanding its single movement?" Now, so far as we may judge, the effect of disturbed gravitation is the formation of equipoise in the form of an ellipsoid, whereby, as an example, we derive our ocean double tide. In following this idea with respect to these electric and magnetic variations, we are led to the conclusion that in some way or another those phenomena conform to the ellipsoidial law, and that, as a consequence, our globe will revolve between two centres of force, as illustrated in Fig. 6.

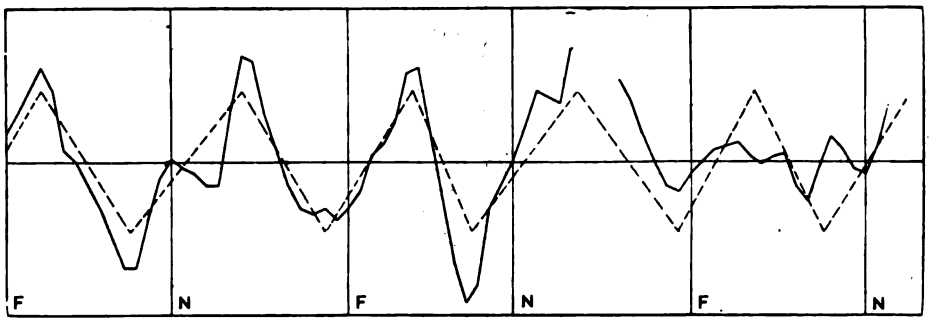

FIG. 4.—Valentia. Earth Current, March 7 to May 27, 1871. Springs and Neaps.

In this diagram, the globe represented by the inner circle is revolving between the two centres of force S and S. The effect of S and S will diminish in all directions; and the spot upon the earth's surface—here represented by the middle circle—will, in revolving from 6 a.m to 6 p.m., and from 6 p.m. to 6 a.m., strike the single line radials from S and S at various points, the values of which are stated by figures underlined. In like manner, a similar treatment of T^2, where S and S are greater than in T^3 as 5 is to 2, and where the elliptical eccentricity is proportionately extended, gives the following hourly values, counting from 6 a.m. to 6 p.m. inclusive:—0·26, 56, 84, 110, 126, 133, 126, 110, 64, 56, 26, 0. Of course, similar values hold good for the other half of the day. In applying this treatment to T^1, it must be on the assumption that whereas the ellipse in the case of semi-solids and liquids will be equally distributed as regards the globe, as in Fig. 6, in the case of more elastic material, such as occupy the far higher regions of our atmosphere, the sun's attraction will so overpower that of the earth as to pull the atmospheric ellipse away towards itself. Thus, whilst the cosmic operation is one and the same for the three T's, the actual result in the case of T^1 will, of necessity, be a diurnal single movement. Granting T^1 a maximum S of 500, at a distance twice that of T^2, we obtain the following figures, counting from midnight to noon inclusively:—0, 0, 0, 10, 25, 47, 73, 100, 127, 157, 186, 208, 214. The same holding inversely for the other half of the day.

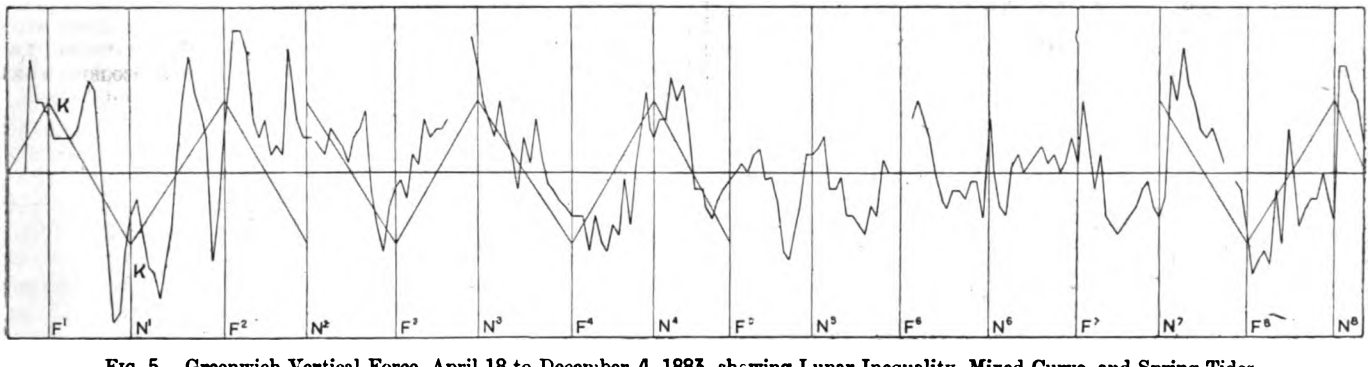

FIG. 5.—Greenwich Vertical Force, April 18 to December 4, 1883, showing Lunar Inequality, Mixed Curve, and Spring Tides.

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The mean value of the forces derived in this way over a period of several days, always allowing for lunar-lag, is shown by the dotted curve in Fig. 1, and when it is remembered that the effect of lunar-inequality, declination, and orbital variation, and the enormous displacement caused by priming are neglected, the result may be considered as closely approximating actual to the variations we have had under review.

It may be objected that the lunar-inequality effect, instead of being greater than the solar-inequality, is, in reality, much less; but it may be replied that the rarefying influence of the sun's heat upon the atmosphere may indirectly augment the in equality in its case.

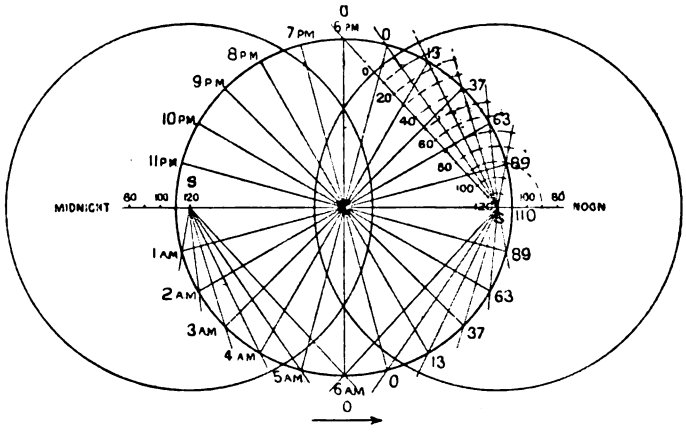

FIG. 6.

In respect of the view here advanced further evidence could be adduced, and we hope to widen the subject in a future Paper.

THE ELECTRIC TRANSMISSION OF POWER.*

BY GISBERT KAPP.

LECTURE III.

(Continued from page 396.)

As an example of a large modern transmission plant, I select, for illustration, that erected a few months ago for the Schaffhausen Spinning Mills. This example is not only interesting on account of its magnitude, but because it has been planted, so to say, into the very stronghold of rope transmission, namely, at the Falls of the Rhine, where the last generation of Swiss engineers carried out such admirable work in teledynamic transmission that the present generation can only copy, but cannot improve upon it.

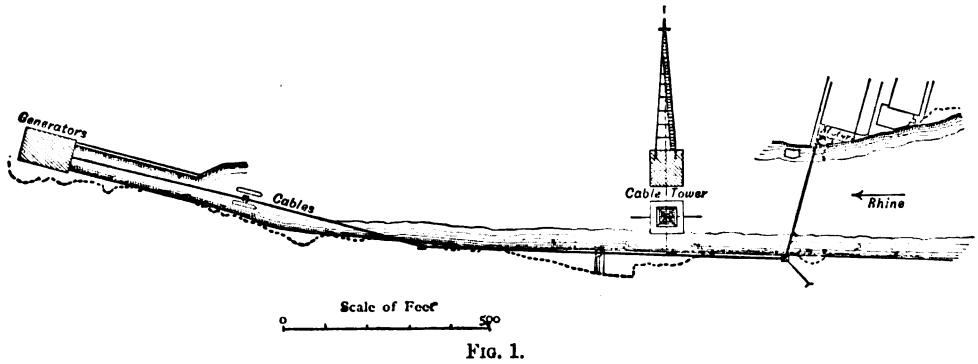

FIG. 1.

And the grand example set by Redtenbacher, Amsler, and others, on the Rhine has, as a matter of fact, been largely copied at other places. There is hardly a large engineering works in Switzerland or the South of Germany where rope transmission in some form or other will not be found, but the best days of this system are passed. Till recently, rope transmission held the field absolutely, not because it was perfect, but because there was nothing better. Now, however, we have something better in electric transmission, and the flying ropes are being steadily replaced by the electric conductors. In the first place, the capacity of teledynamic transmission to deal with large powers is limited. During last year, the Niagara Commission inspected a large number of plants in Europe, and came to the conclusion that 330 H.P. is the very utmost which can be dealt with by a single rope, so that above this power we must employ more ropes with a corresponding complication in the gear. I need hardly say that no such limit exists in electric transmission. But there are other difficulties in connection with ropes. They wear out very fast, their support at the translating stations on the line requires the erection of very heavy and costly structures, and they are largely influenced by climatic changes, causing excessive strains at some times, and slipping at others. These considerations have induced the managers of the Schaffhausen Spinning Mills to adopt electric transmission in the very spot where rope transmission, in years gone by, has received its most perfect development possible.

The situation of the works is shown on the diagram (Fig. 1). The spinning mills are on one side, and the generating station is on the other side of the river, the distance between the two being about 750 yards. In the generating station there is room for five 350 H.P. turbines, of which four are now in place, but of these only two are as yet used in connection with the electric power transmission I am about to describe. The power of these turbines is sold to the Spinning Company at the rate of £2. 16s. per annual horse-power taken off the rope pulleys (Fig. 2). The turbines are horizontal wheels, and their vertical axes are geared by bevil wheels with the rope pulleys, by which motion is conveyed through cotton ropes to the two generating dynamos. The latter are six-pole machines, each designed for an output of 330 amperes at 624 volts, and in regular work these machines are coupled parallel. The machines, and, in fact, the whole installation, with the exception of the hydraulic works, has been designed by Mr. Brown, to whom I am indebted for the particulars I now bring before you. The electrical part of the plant was made and erected by the Oerlikon Engineering Works. The line consists of four cables (each having an area of ·437 of a square inch), and is supported at four intermediate points, besides the supports at the terminuses. One of the intermediate supports is the old turbine house, which, in former times, was used in connection with the wire rope transmission; the others are towers of iron framework, 46ft. high, one of which is shown to a larger scale in Fig. 1. The span where the line crosses the river is 330ft., and where it passes along the shore of the river the span is 430ft.

You may imagine that the proper support and insulation of cables of that size, and with so long a span, is a matter of considerable difficulty. The use of glass or earthenware insulators on a stalk, as employed for the support of telegraph lines and other light wires, is, of course, out of the question. We must have something very much more substantial, and this has been provided in the manner shown in Fig. 5 (p. 418). Near the top of each post there are bolted to the iron framework four of the boxes shown on this diagram—one for each line of cables. The inner box serves as a kind of junction or connecting piece between the cable ends, which are opened out, as shown. Molten zinc is then run in, and surrounds every single wire, thus making a perfect electrical joint; whilst at the same time, the strain is divided between all the wires in the most even way possible. The inner box is surrounded by an outer box, and the intervening space is cast out with sulphur, which is an excellent insulating material, and, applied in this way, of sufficient mechanical strength to resist the large forces involved in the supporting of these heavy cables.

In mountainous countries, where thunderstorms are frequent and violent, the protection of lines from lightning strokes is a matter that must not be overlooked. The line I am describing is protected in a two-fold manner. In the first place, there is stretched over the four electric cables a steel wire rope, passing right over the supports, and in good electric connection with their iron framework, and therefore with earth. The object of this arrangement is to act as an ordinary lightning protector, on the supposition that a lightning flash will rather go to earth by way of the steel cable and one of the towers that run along the electric line. But light-

* Cantor Lectures delivered before the Society of Arts, February and March, 1891.

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ning flashes are sometimes very erratic, as was shown experimentally in this very room, in the admirable "Mann Lectures," which Prof. Lodge delivered before this Society in 1888. It is, therefore, also necessary to make provision for flashes which will, for some reason or other, stray away from the direct path provided for them; and this has been done in the Schaffhausen installation, by the employment of lightning arresters at both terminal stations. At each station there are four lightning arresters, one for each cable. They consist of a pair of toothed plates, of which, however, only one is fixed, the other being movable. When a flash strikes one cable only, it goes to earth by the corresponding plates, and no further damage is done.

Fig. 4 shows a drawing of these generators. Fig. 3 is a drawing of the twin motor, which receives the bulk of the power at the spinning mills, whilst the remainder is taken up by a couple of two-pole motors, placed in other parts of the mills. These are not shown on the diagrams, as they are of the ordinary design, with which you are already familiar. The twin motor is rated at 380, and each of the single motors at 60 H.P., making in all 500 net brake H.P. delivered to the mill shafting. The coupling between the motors and the mill shafting is by cotton ropes, as shown in Fig. 3, the arrangement chosen having the advantage that very little side strain is thrown upon the motor bearings, owing to the ropes pulling opposite ways.

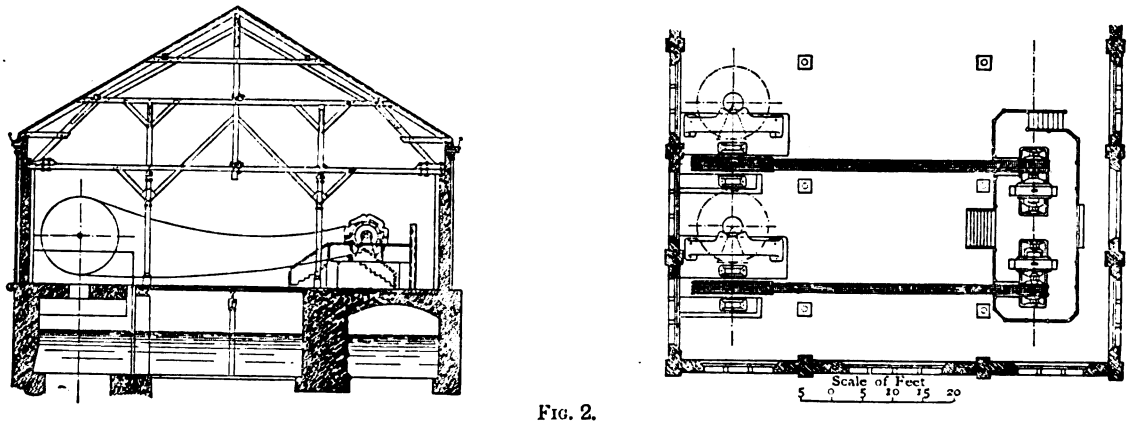

FIG. 2.

Should, however, both a positive and a negative cable be struck at the same time, then the arc set up between the plates by the passage of the lightning flash provides an easy path for the passage of the power current also; in other words, the generator will be short-circuited. The object of making one of the plates movable is to

An interesting and novel feature of the plant is the arrangement adopted for starting gradually, and yet without the use of resistance. In my experiments last week I used current delivered at constant pressure; and, to start the motor gradually, and prevent sparking at the commutator, I was obliged to insert into the armature circuit a

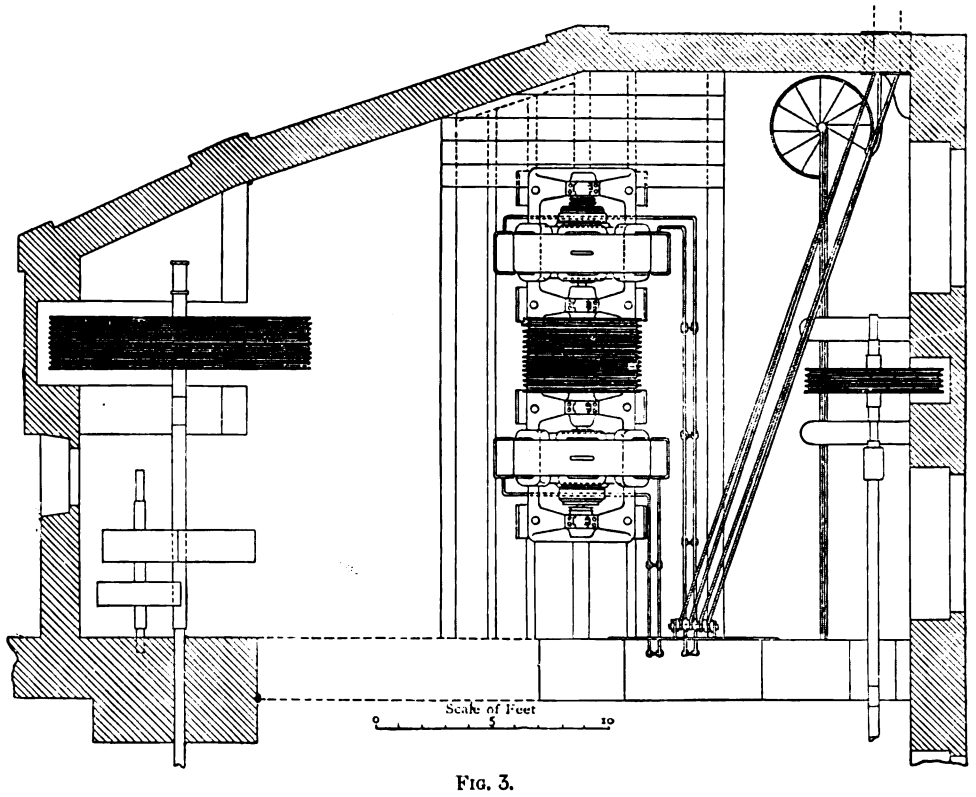

FIG. 3.

cut off the short circuit current before any harm is done to the machinery. The movable plate of the lightning protector is connected to the core of a solenoid, through which the short circuit current must flow. Immediately this current is started, the core is sucked in, and the movable plate falls away from the fixed plate, thus acting the part of an automatic switch.

Returning now to the Schaffhausen plant, the generating station contains two 300 H.P. dynamos, which are over-compounded, so as to produce a constant pressure of 600 volts at the motor station, the loss in the line being with full current 24 volts. These machines have series-wound drum armatures, running at 200 revolutions per minute. Their more important electrical data, as well as those referring to the motors, are given in the table on the next page.

variable resistance, which was withdrawn after the motor had gathered enough speed to make this safe. There is no inconvenience in using such a resistance when we are dealing with small currents; but when it is a question of several hundred amperes, and the absorption of as many horse-power, the resistance becomes a very cumbersome and unwieldy appliance. To get over this difficulty, Mr. Brown has devised a very ingenious method of coupling between the line and machines, the essential features of which are shown in Fig. 6. As I have already mentioned, there are four main cables, two positive and two negative. Three of these cables contain no switches which need be used for starting, although of course they contain the switches and fuses which may be required for testing purposes and as safety devices, but these, not being

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essential to the explanation of the starting arrangements, I have not shown in the diagram. Call the two outer cables positive, and the two inner cables negative. The positive cables are looped at both terminuses, and the inner cables are also looped in this way, but a switch is inserted in the right-hand cable at the motor station.

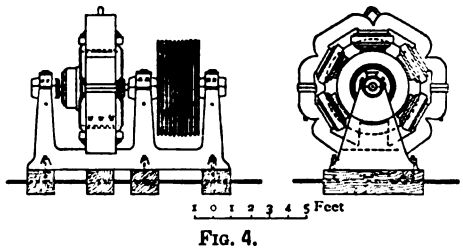

FIG. 4.

Now imagine all the machines at rest, and this switch to be open. To start the plant, the turbine-driven generator, G_1, is set in motion, and the speed run up till this machine excites itself by its

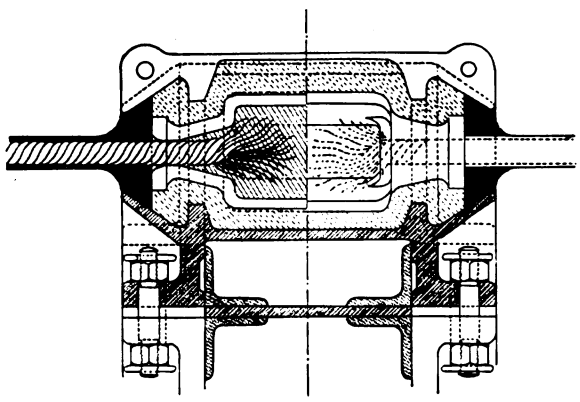

FIG. 5.

own shunt. If you follow the connections you will find that the shunts of the other three machines will at the same time also become excited. The motors have now made their fields, and if we start the second generator, G_2, slowly, a power current of gradually increasing strength will be sent through both motors, and the

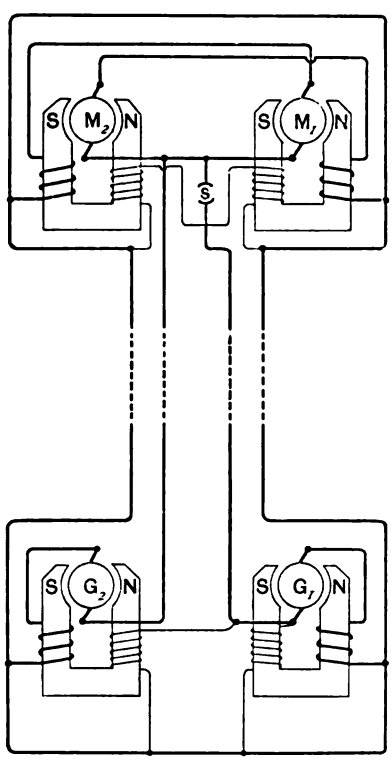

FIG. 6.

latter will gradually start. As they gather speed, their counter E.M.F., which is indicated by a voltmeter at the motor station, gradually rises; and if it has become equal to the E.M.F. indicated by a second voltmeter in connection with the current from the first generator, G_1, the attendant closes the switch, and the operation of starting is completed. It should be noted that on closing this switch there is no sudden rush of current, since the pressure on both sides of the switch is approximately equal.

Originally the motors were intended to be pure shunt machines, but it was soon found that, owing to the very small armature resistance and armature reaction, it was very difficult to get the load equally divided between them. Mr. Brown, to overcome this difficulty, hit upon the ingenious device of making the machines mutually control each other by putting on demagnetising main coils, and crossing the connections between armatures and fields, so that the machine, which might at any moment develop a tendency to take more than its fair share of current, would have its field strengthened by the deficiency of current passing through its main turns to the other armature, and would thus immediately raise its counter E.M.F., and check the excess of current, whilst the other machine which was not taking enough current, would have its field weakened, and would thus be forced to take more current. It is clear that by this cross-connection even a neglect on the part of the attendant to set the brushes properly cannot materially influence the even division of current and load between the two machines. At the same time the demagnetising influence of the main coils has the same effect as if the armature reaction was increased, and insures thus constancy of speed, as I have shown you experimentally last week. In the diagram, Fig. 6, the machines are represented as if they had only two poles each. This I have done to make the diagram as simple as possible, and for the same reason I have shown the shunt and main coils on separate magnet limbs, but you will have no difficulty in translating in your own mind this principle of circuit connections to multipolar machines.

It may interest you to have a few details of a commercial nature regarding this transmission plant. The manufacturers have guaranteed a commercial efficiency at ordinary full load of 78 per cent., also that the machines must be capable of transmitting an excess of 20 per cent. over their normal power for one hour and a-half without damage. The wear of one set of brushes to be not less than 2,000 hours, and the life of a commutator not less than 20,000 hours. The variation of speed of the motors between running idle and under full load not to exceed 3 per cent. The total cost of the electrical part of the plant, including cable towers and erection, was £6,800, or £13. 12s. per net horse-power delivered.

Schaffhausen Transmission Plant.

	Generators.	Twin motor.	Small motors.
Number of machines	2	1	2
Normal horse-power	300	390	60
Number of poles in magnet field	6	6	2
Revolutions per minute	300	380	350
Terminal voltage	624	600	600
Normal current amperes	330	500	81
Diameter of armature inches	47½	42⅛	23⅝
Length of armature core inches	20	20⅜	22⅛
Radial depth of armature core inches	8	7	4¾
Section of armature conductor square inches.	·103	·078	·0287
Number of armature conductors	316	316	540
Number of commutator segments	153	153	90
Loss in armature resistance per cent.	1·46	1·52	2·7
Induction in armature C.-G.-S. measure	7,500	7,600	15,800
Shunt resistance ohms	140	143	295
Loss in shunt excitation per cent.	1·35	1·68	—
Main turns per magnet	6	4	—
Loss in main excitation per cent.	3	2	—
Type of armature	Drum.	Drum.	Cylinder.

(To be continued.)

THE PROPAGATION OF ELECTRIC DISTURBANCES ALONG CONDUCTING WIRES.

In *La Lumière Électrique* of August 8th, Prof. Hertz offers some remarks on a contribution to that journal by M. J. Blondin, which appeared in its issue of July 18th. M. Blondin opened his article with the following remarks :—"According to Maxwell an electric disturbance should be propagated along an insulated conducting wire with the same speed as through the dielectric medium surrounding it. To show that this is so would, therefore, contstitute an invaluable verification of the truth of the theories of the English *savant*. The determination oi the speed of propagation of electric waves in metallic wires has been of late the subject of much work, the most important of which has been described in this journal (*La*

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Lumière Électrique). Unfortunately, the contradictory results arrived at, so far from confirming the theory of Maxwell, seemed to show that it could not be applied without modification to propagation along conductors, and it is only quite recently that the question has been definitely settled in a sense favourable to Maxwell's ideas by the work of MM. Sarasin and de la Rive.* I therefore think it useful to take up the systematic study of the propagation of periodic electric disturbance along a conducting wire."

To this systematic study Prof. Hertz replies as follows :—"M. Blondin treats in an extremely just and kind manner certain errors which, it seems, have crept into my researches. I have scarcely anything to add to the very clear explanation of M. Blondin, and I am only desirous of taking this opportunity of myself stating in this journal that the conclusions which M. Blondin arrives at are in perfect accord with my present conviction, although they disagree with the results of the experiments which I published a few years ago. When I began these experiments, I was inclined to think that they ought to furnish two identical speeds, and I was astonished and disappointed to find that experiment gave unequal speeds. On this account I am fairly confident that I did not carry out my experiments with preconceived ideas, and in repeating them at the same place and under the same conditions I over and over again obtained the results published in my Papers. This does not preclude the idea that local conditions, either unknown or badly interpreted, had a disastrous influence, and falsified the results. To see if this were so, I endeavoured to repeat the reflection experiments in my present amphitheatre, which is a fine room, 17 metres long, 12 metres broad, and 5 metres high, without iron pillars to interfere with the experiments. I was, therefore, hopeful of obtaining excellent results and certain success. Unfortunately, the benches, which I was unable to remove, were ranged one above another in tiers in such a manner that I was obliged to give to the waves a somewhat inclined direction, unsymmetrical with regard to the horizon and the walls of the room. Under these conditions for waves several metres in length, the experiment succeeded very badly. The interference phenomena were much less pronounced than I had usually found them ; the nodes were so ill-defined that their true position remained doubtful to within more than a metre. Once again, therefore, I was obliged to give up the idea of personally experimentally verifying the facts.

"Nevertheless, these experiments enabled me to ascertain how great may be the influence of local conditions on long waves in a room of moderate dimensions and not completely empty. I even think that any such closed space complicates vibrations and produces effects analogous to acoustic vibrations in cubic tubes ; that is to say, tubes the dimensions of which are approximately all the same. If this is so the intensity of the disturbance and its distribution in space will depend in a large measure on the relation which exists between the period of the exciter and the period of the vibrations proper to the closed space, on the position of the exciter relative to the nodal surface of the simple vibrations, &c., &c.

"Perhaps we shall find in these considerations a possible explanation of the diverse results obtained ; in any case I do not publish them as a proven explanation. However, it does not seem to me that the beautiful experiments of MM. Sarasin and de la Rive were carried out under better conditions than were my own. If any physicist has at his disposal a large gallery, 8 metres high and 8 metres broad, and from 20 to 40 metres long, I think that even now it would not be lost labour to repeat these experiments on a large scale in order to remove the last uncertainty from science. I do not doubt that such an experiment would verify the results of the Geneva physicists. In a laboratory of ordinary dimensions, I think it would be very difficult to get a certainty greater than that already obtained."

CONTRIBUTIONS TO THE THEORY OF SECONDARY CELLS.†

BY F. STREINTZ.

This Paper considers the capacity and efficiency of elements with positive plates of various sizes. For the experiments E.P.S. plates, supplied by Messrs. Getz and Odendall, of Vienna, were sawn up so that the cut passed through the middle of the lead framework. The active material was thus not interfered with. Three elements were tested : in I., the positive plate contained 5×5 meshes of the lead network ; in II., 5×6 ; and in III., 6×6 ; the distances between the elements in each case were 1·5cm. In a larger vessel was placed an amalgamated zinc plate in dilute sulphuric acid ; by means of a glass syphon this could be put into communication with the contents of each of the three elements, for the purpose of determining the potential difference between the zinc and the plates of the accumulators.

The experiments were conducted as follows :—The element was first charged by a known current for several hours beyond the point at which the negative plate began to give off hydrogen. It was then discharged with the same resistance in the conductors until the current strength fell 10 per cent. below its stationary value. This discharge, during which the potential and current strength were taken every hour, served to determine the capacity. On the following day it was again charged at the same current, but this time the charging was stopped as soon as hydrogen began to be given off ; finally came a discharge under similar conditions, following usually immediately upon the charge. The observations taken during the second charge and discharge served to determine the efficiency.

The tests showed that the capacity, *i.e.*, the number of watt-hours which an element was capable of giving out before the current strength fell 10 per cent., increases as the current strength diminishes. The element II. showed the highest capacity of the three.

It was demonstrated that a reduction in the size of the positive plate conduces to an increase in the capacity, the efficiency at the same time not being lowered.

* See *The Electrician*, Vol. XXVI., April 10, p. 701.

† *Wied. Ann.*, Vol. XLIII.

LONDON CHAMBER OF COMMERCE.

MEETING OF THE ELECTRICAL TRADE SECTION COMMITTEE.

A meeting of the Committee of the Electrical Trade Section of the London Chamber of Commerce was held, on Friday last, at Botolph House, Eastcheap, for the purpose of conferring with the Directors of the Crystal Palace Company as to the desirability of postponing the proposed Electrical Exhibition. Mr. R. E. Crompton occupied the chair, and amongst those present were Messrs. Moritz Immisch, R. S. Erskine, G. Binswanger, Shirley Price, E. J. Paterson, George Offor, W. J. Rivington, W. T. Goolden, Musgrave Heaphy, and R. Applegarth.

The CHAIRMAN opened the proceedings by reading a lengthy letter from Major Flood-Page, suggesting the advisability of postponing the Exhibition until July next, and the probability, in that event, of the Crystal Palace Company securing the support of a joint Committee of the Section and of the Council of the Institution of Electrical Engineers.

On the Directors being introduced, the CHAIRMAN laid Major Flood-Page's letter before them, and said that he understood they had come together in order to arrive, if possible, at some agreement as to the advisability, in the interests both of the Crystal Palace and of the Electrical Trade, of postponing or of going on with the proposed Exhibition.

Captain HENSHAW RUSSELL (Manager of the Crystal Palace) said that he had already received sufficient applications for space to occupy the entire area available. Over 50 firms (56 he thought was the exact number), many of them first class firms, such as Johnson and Phillips and Easton and Anderson, had applied. The object of the Crystal Palace Company was, of course, to make the Exhibition representative, but it must be remembered that the Company was under certain obligations to the firms who were prepared to exhibit in November. For his part, he thought July a very bad month indeed to open an Electrical Exhibition. For an electric lighting show the winter time was, in his opinion, the best ; they then had four or five hours every evening, instead of one, during which they could light up.

The CHAIRMAN said that the feeling of the trade was that they had been in a constant state of exhibiting since the first one at the Palace. He thought, however, that a thoroughly representative and exhaustive Exhibition, accompanied by trials of plant, would be of some good to the industry, but such an Exhibition could not be got together without considerable preparation.

One of the Directors suggested, as a compromise, that the date of opening should be postponed until the 1st of January.

Mr. G. T. RAIT, of the Crystal Palace Company, asked the Committee to remember that it was the Crystal Palace Company which would have to bear the financial risk of the Exhibition. The Directors were indebted to the Section for the interest it had taken in the matter, and they cordially invited the Section and the Institution of Electrical Engineers to support them. The Crystal Palace Company were, however, of opinion that the Exhibition should go on.

The CHAIRMAN failed to see where the financial risk of the Crystal Palace Company came in, and thought the exhibitors ran the most risk. If the Exhibition failed to attract *customers* the trade would regard it as a failure, but the Crystal Palace Company

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had only to attract the shilling-paying public. He was afraid they looked at the matter from two different points of view.

After a few further remarks the Directors withdrew, and a discussion ensued, in the course of which Mr. OFFOR stated that if the Exhibition came off, the Company he was connected with was prepared to transmit 400 H.P. to the Palace, from a distance of 1½ miles, on the continuous-current transformer system.

The following resolution was finally proposed by Mr. GEORGE OFFOR, seconded by Mr. SHIRLEY PRICE, and carried :—

"That, in the opinion of the Electrical Trade Section of the London Chamber of Commerce, the offer of the Crystal Palace Company to postpone the opening of the Exhibition to January 1st, 1892, while affording a compromise in point of time, is not entirely satisfactory, but, in view of the fixed determination of the Directors to hold an Exhibition, this meeting advises firms in the electrical trade to support it as far as possible under the circumstances."

Mr. W. T. GOOLDEN then proposed, and Mr. MORITZ IMMISCH seconded, the addition of the following rider :—

"At the same time, this meeting strongly urges that the prospects of the success of the Exhibition would be greatly improved if the Directors could see their way to still further postpone the opening of the Exhibition until the autumn of 1892, which would appear to be a very favourable date for holding an Electrical Exhibition."

On being put to the meeting this was unanimously agreed to.

The Secretary was requested to intimate, in forwarding this resolution to the Secretary of the Crystal Palace Company, that, in accordance with the suggestion which they had made to the Directors in conversation—a suggestion which the Directors had welcomed—that they would be prepared to appoint a Committee to co-operate with the Crystal Palace authorities in their efforts to make the Exhibition a success, on being formally invited to do so.

The CHAIRMAN then read a list of the firms who had, in response to the Chamber's circular, agreed to visit the Frankfort Exhibition in the form of a party from September 5th to 15th. The Chairman and Mr. Binswanger agreed to co-operate with the Secretary in making the necessary arrangements for the party, such as hotel accommodation, &c.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *August* 1, 1891.

Electrical Business.—News from Pittsburgh states that the Westinghouse Company is now pretty completely reorganised, and that the outlook there is brighter than it has been for many months. The Edison Company has recently been pushing its mining machinery, especially the reciprocating rock drill, but of the long predicted alternating current system there are no signs as yet. The Directors of the Company have not yet made up their minds what they want to do about prosecuting infringers of the lamp patents. Presumably the next few weeks will develop a definite policy of some sort or other. Of the larger electrical companies the Thomson-Houston is at present the most active and, a large number of installations are under way, though none of them of any great size. The bulk of electric lighting work in this country is done in towns and the smaller cities, especially through the West, so that although the aggregate is considerable, no individual job is of any formidable size. The Edison lamp decision is still a fruitful theme of conversation, and it is singular to notice how general seems to be the opinion that the decision was influenced by the great reputation of the inventor? Still, even the opponents of the Edison interests acknowledge that the moral effect of a strong decision sustaining an important patent is excellent, for so many patents have been broken down recently that inventors are far from being encouraged.

Rapid Transit in New York.—The Rapid Transit Commissioners have, as you have probably noticed through the daily papers, planned a subsidiary route up the east side of New York City. They have carefully abstained so far from giving any useful information as to the probable nature of the underground structure they propose erecting. The two still most important are the Reno and Greathead systems of tunneling. The former being a four-track tunnel that is looked upon with considerable favour by the commissioners; the latter being too familiar to you to need comment. Mr. Frank J. Sprague has shown himself very strongly in sympathy with the Greathead system, although whether he has any official connection with it is unknown. He is certainly abundantly able to push the electrical work through to success whatever form the enterprise may take. Meanwhile the cable road on Broadway is going down rapidly, in spite of the rumours that have from time to time gained currency that this plan was to be abandoned. The borings made by the Rapid Transit Committee along Broadway show that the task of tunneling in the lower part of the city will be comparatively easy, as rock is not encountered in quantity until the vicinity of Union Square is reached; above that point the engineering work will present few great difficulties, but a very large amount of rock cutting will have to be done.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

NOW READY.—"THE ELECTRICIAN" PRIMERS (38 in all, Vol. I., 20; Vol. II., 18), in two volumes. Price per volume 2s. paper covers, 2s. 6d. cloth; post free, 2s. 2d. and 2s. 9d. respectively. Single copies, 3d.; post free, 3½d. Prospectus on application to the Publisher.

TENDERS INVITED.—EXTENSION OF TIME.—The time for delivery of tenders for lighting the Southampton Royal Pier by electric light, and providing and fixing two electric cranes on the Town Quay, has been extended to September 8th. Further particulars will be found in our advertisement columns.

SALE BY TENDER.—Mr. Frederick Miller announces in our advertisement columns that, by direction of the Official Receiver, he will sell by tender the electric appliances belonging to Mr. J. Scott, at 13, Apple-tree-yard, York-street, St. James's, and Marylebone-mews, High-street, Marylebone. The stock may be viewed on Wednesday and Thursday next, and forms of tender may be obtained at the vendor's office, 2, Soho-street, Lincoln's-inn-fields, W.C.

MESSRS. W. T. GOOLDEN AND CO.—We are pleased to learn that at this, the slackest time of the year in the trade, this firm are very busy, and have in hand a large number of dynamos for lighting as well as complete plants for transmitting power.

PRIESTMAN'S OIL ENGINE FOR ELECTRIC LIGHTING.—About two years ago Priestman's Oil Engine was put upon the market, and the makers assure us that the progress made has been very satisfactory. A large number of orders have been received for engines varying in size from 1 to 25 actual H.P. for electric lighting, and Messrs. Priestman's works have been largely extended, with a view to giving prompt deliveries. It is claimed for this engine that it runs with exceptional steadiness and great regularity; can be easily fixed; is not dangerous, having no boiler to burst or keep in repair, requires no driver, and therefore works with great economy, can be kept in good working order by an unskilled man; and finally that, using only heavy mineral oil, no extra insurance is charged. Amongst orders recently executed for electric lighting may be mentioned a second order from Messrs. B. Verity and Sons, a third order for a 9 H.P. engine from Mr. F. M. Newton of Taunton, a second order for a 5 H.P. engine from Messrs. Anderson and Munro, and the New South Wales and Victorian Governments have recently adopted the Priestman engine for electric lighting purposes, the latter using a 25 H.P. engine. Mr. W. J. S. Barber-Starkey has recently given the following testimony :—"I have for the last nine months used one of Messrs. Priestman's engines for electric lighting, and it has given me every satisfaction. As I have it arranged the charging current is so steady that the needle of the ampere meter placed in the charging circuit shows hardly any perceptible fluctuation."

GAIETY THEATRE, DUBLIN.—An electric light installation has just been fitted up in this theatre by the Electrical Engineering Company of Ireland, under the supervision of their engineer, Mr. Porte, and of Mr. Harry South, of Garrick-street, London. Two Otto gas engines of 14 H.P. each drive two compound-wound dynamos, built by Messrs. Lawrence, Scott and Co., of Norwich, which supply current to 250 lamps. A feature of the installation was the rapidity with which it was fitted up, everything having been done within three weeks of the order being received.

ANNUAL DINNER.—The *employés* of Messrs. Swinburne and Co., of Teddington, held their first annual dinner on Friday last. A feature of the outing was the journey from Staines to Windsor in a steam launch. Notwithstanding occasional showers, a pleasant day was spent.

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PATENT RECORD.

APPLICATIONS FOR PATENTS.

July 7, 1891.

11,497. J. McLaren. Edinburgh. An hydro-electric lift.

11,519. E. A. Le Sueur. London. Improvements in diaphragms for electric cells.

11,526. F. G. W. J. Adams. London. Improvements in and connected with portable electric lamps, and in primary electric batteries and lenses for deflecting light to be used therewith.

11,538. G. Prokofiew. Chiswick. An electric traction magnetic conductor.

11,539. G. Prokofiew. Chiswick. An improved dynamo machine.

11,560. G. G. M. Hardingham. London. Improvements in and relating to galvanic batteries. (J. R. Hand and H. Connett, United States).

July 8, 1891.

11,620. E. E. Lever. London. Improvements in apparatus for preparing bleaching solution and bleaching powder by electrolysis.

11,625. J. H. Holmes. Liverpool. Improvements in the method of and apparatus for making electrical connections.

11,644. I. A. Timmis. London. Improvements in the lighting of trains by electricity.

11,645. R. B. Evered and T. Rudling. London. Improvements relating to combination gas and electric fittings, and to gas fittings.

July 9, 1891.

11,668. J. Parkes. Liverpool. Electric lighting of ships' compasses transparent cards.

11,712. H. C. Bull. London. Improvements in or connected with electric batteries.

July 10, 1891.

11,720. J. H. Tucker. Erdington. Improvements in electrical switches.

11,746. F. Van Houten. London. Improvements in telegraphic apparatus

11,756. W. Brock and W. H. R. Saunders. London. Improvements in electrical railway signalling.

11,762. G. H. Dörken. Barmen, Germany. A button commutator or cut-out.

11,767. J. E. Kingsbury. London. Improvements in telephone switchboards.

July 11, 1891.

11,801. R. D. Haines. London, Improvements in the manufacture of insulating conduits, or coverings for electric conductors. [Date applied for under Patents Act, 1883, Sec. 103, 12th December, 1890, being date of application in United States].

July 13, 1891.

11,836. A. Cance and Societe Anonyme d'Appareillages and d'Eclairages Electriques. (Lampes Electriques Cance). London. Improvements in electric arc lamps.

11,891. W. P. Thompson. Liverpool. Improvements in and relating to switch devices for effecting the connections in telephone systems. (J. Dietz, Germany).

July 14, 1891.

11,964. H. E. Newton. London. Improvements in accumulators for direct-acting engines. (C. P. Worthington, United States).

July 15, 1891.

11,978. A. R. Upward. London. A system and apparatus for the evolution and diffusion by electrical energy of disiufectants, antiseptics, and substances of a like nature.

12,004. R. Whitehead and A. Doxey. Sheffield. An improved microphone transmitter.

12,014. A. T. Collier, A. Marr, and W. F. Bottomley. Manchester. Improvements in telephonic transmitters.

12,018. E. Wilson. Charlton. Improvements in electrical gear for steering ships, and controlling the movement of holophotes, guns, and the like.

12,019. W. L. Wise. London. Improvements in the manufacture of carbons for electric arc lamps. (The Rheinische Fabrik for Elektrische Bogenlichtkohle W. Grüdelbach, Germany).

12,036. S. W. Maquay. London. Improvements in primary batteries.

12,040. A. A. Dykes and W. B. Hird. London. Improvements in voltmeters.

12,046. J. Sahulka. London. Improvements in or relating to electric motors.

July 16, 1891.

12,069. H. D. Fitzpatrick. Glasgow. An improved electrode plate for electric collectors. (K. F. Schöller and R. H. Jahr, Germany).

12,070. H. D. Fitzpatrick. Glasgow. An improved method of reciprocating the anchor of an electric apparatus. (K. F. Schöller and R. H. Jahr, Germany).

12,009. S. W. Maquay. London. Improvements in electric motors.

12,106. F. V. Maquaire. London. Improvements in and relating to electric lamps or lighting apparatus.

12,107. W. E. Dow. London. Improvements in drops or suspending mechanism for electric light and other like fittings.

12,117. E. Hartmann and W. Braun. London. Improvements in electric current meters.

July 17, 1891.

12,133. R. J. Bott. London. Improvements in the automatic contacts of incandescent lamp holders.

12,188. R. H. Barrett. London. Improvements in and in connection with incandescent electric lamps.

July 18, 1891.

12,244. J. S. Nettlefold. London. Improvements in portable electric lamps.

12,257. P. Scharf and R. Latzko. London. Improvements in the manufacture of electric incandescent or glow lamps.

July 20, 1891.

12,285. A. A. Goldston. Middlesbrough. A magneto advertising or displaying device.

12,286. C. S. F. Mellor. London. Economic electro-motor and motive power.

12,296. A. S. Elmore. London. Improvements in apparatus for the manufacture, by electrolysis, of tubes and other articles of circular section.

12,313. E. C. C. Jungnickel. London. Improvements in electric batteries

July 21, 1891.

12,322. A. J. Boult London. Improvements in or relating to electrica welding. (J. H. Bassler, United States).

12,384. M. Mackay. London. Improved compound for insulating electric wires in general.

July 22, 1891.

12,415. F. E. Stuart. Twickenham. Improvements in and relating to quick hitching harness and its operation by electric current.

12,416. A. Marr. Manchester. Improvements in telephonic transmitters.

12,455. J. Wetter. London. Improvements in electric locomotives. (H. Bonneau, France).

July 23, 1891.

12,484. A. R. Bennett. London. Improvements in telephonic switching apparatus.

12,491. C. L. Baker and Woodhouse and Rawson United (Limited). London. Improvements in the construction of rheostats or similar electrical instruments.

12,503. E. Owen. London. An improved electric ear-ring for curative and remedial purposes.

12,525. G. S. Grimston and A. H. Dykes. London. Electrical steering gear.

12,529. H. Edmunds. London. Improvements in means for distributing electric currents.

12,531. D. Bouchard. London. A new or improved apparatus for producing pictures upon a screen in stereoscopic relief by means of electricity.

12,535. A. P. Newton. London. Improvements in switches for electric installations. (A. Swan, United States).

12,540. H. Cuénod, E. Sautter, and G. Hochreutiner. London. Dynamo-electric machines. [Date applied for under Patents Act, 1883, Sec. 103, December 31, 1890, being date of application in Switzerland].

12,541. H. Cuénod, E. Sautter, and G. Hochreutiner. London. A system for the automatic regulation of the position of the brushes of dynamo-electric motors. [Date applied for under Patents Act 1883, Sec. 103, December 31, 1890, being date of application in Switzerland].

July 24, 1891.

12,592. H. H. Lake. London. Improvements relating to the manufacture or preparation of carbons for electric lamps or lighting apparatus. (Lacombe and Co., France).

12,602. H. Aron. London. Improvements in apparatus for measuring electric currents.

12,605. H. H. Lake. London. Improved means for securing terminals or binding screws to plates or electrodes for electric batteries. (Lacombe and Co., France).

12,611. J. W. Swan. London. Improvements in or connected with the electrolytic deposition of copper.

12,622. N. Wells. Newport. An improvement in electric clocks.

12,628. J. J. Hargreaves and R. W. Nuttall. Bradford. Improvements in couplings and terminal connections for electric cables.

12,634. A. D. Macdonald and J. Dodd. Liverpool. Improvements in apparatus for electrical sound and sight signalling on railways and other lines of rail.

SPECIFICATIONS PUBLISHED.

1890.

10,359. Watson, T. W. and A. H. Electric lighting of ships, &c. (Price 6d.)

11,263. Munro. Electric connections. (Price 6d.)

12,151. Siemens Bros. and Co. (Limited) (Siemens and Halske). Alternate current motion. (Price 8d.)

14,155. Fraser and Brown. Telephonic switch-boards. (Price 8d.)

14,182. Fraser and Brown. Telephonic switching apparatus. (Price 8d.)

14,686. Lake (Lacombe and Co.). Electric lamp carbons. (Price 4d.)

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1891.

5,638. CROWDUS. Electric batteries. (Price 8d.)

7,755. LAKE (The Crocker-Wheeler Electric Motor Company). Electric motors. (Price 8d.)

9,029. TURBAYNE. Electric arc lamps. (Price 6d.)

9,241. THOMPSON (Harding). Electric railways. (Price 8d.)

9,462. ALCOCK. Electrostatic switch, &c. (Price 6d.)

9,522. STANLEY and KELLY. Electro-magnetic motors. (Price 6d.)

9,524. STANLEY and KELLY. Telephone circuits. (Price 6d.)

9,627. ABEL (Gülcher and another). Thermo-electric batteries. (Price 8d.)

9,928. SCOTH. Galvanic batteries. (Price 4d.)

COMPANIES' MEETINGS & REPORTS.

Cuba Submarine Telegraph Company (Limited).

The fortieth ordinary general meeting of the shareholders of this Company was held at the offices, 58, Old Broad-street, on Wednesday, under the presidency of Mr. Thomas Greenwood.

The CHAIRMAN, in opening the proceedings, said: The Secretary will read the notice convening the meeting.

The SECRETARY (Mr. James Scott) having read the notice,

The CHAIRMAN said: The Board has very little intelligence for you to-day beyond that already given in the report. As so many shareholders failed to attend these meetings, the Board has always been very anxious to give in the report every information to them that they are likely to want. I apprehend that you have made yourselves acquainted with the purport of that document, and that it need not be read before I move the adoption of the report and accounts. I may, however, draw your attention to a few points that may be of interest to you. The receipts of last half-year compared with those of the corresponding period of the previous year were not quite so large. That was not owing to any want of trade, but to the impediments caused for a few days by the breakdown of our cables. As, however, we have our cables now duplicated from end to end, it is highly improbable that such a circumstance will occur again, and, therefore, we may expect that the public service will be continued without interruption and with no loss to the Company. The repairs have been completed during the half-year, and the charge has been rather less than in the corresponding period of 1890; the result is that we have ra her a larger sum to carry to the credit of our reserve fund. The reserve fund, as you see, now amounts to £78,000. We have spent about £22,500 upon new cable, so that but for that outlay, which really is property invested for use, our reserve fund would now amount to rather over £100,000. I think that that is a very satisfactory state of affairs. The suit with the Spanish Government makes slow progress. Lawsuits even in England do not go very fast, and in Spain I think that the lawyers are, perhaps, rather more lethargic than they are here. The Government has lodged in the Court the papers in their hands which it was necessary for them to do before any further steps could be taken, and we have made our plaint. It was lodged within 10 days, the time allowed for such cases. The case is before the Court now, but when it will come on for hearing I cannot say. The delay has not been prejudicial to us. All that we want, indeed, is that there may be perpetual delay. We want a decision that the Government have not the right to grant this concession, and until that is decided against us we are going on with our business, and our opponents can do nothing. So far, delay is beneficial to us, and we have no cause to complain on that ground. I am not aware that there is anything more in the report, or in the circumstances of the Company as a whole, that I need mention to you, but if there is anything further upon which you may be desirous of receiving information, we shall be very pleased to furnish it. The formal resolution which I have to propose is:—

"*That the report and accounts for the half-year ended June 30th last, now submitted, be received and adopted.*"

Mr. ALEXANDER F. LOW: I beg to second that.

Mr. COCHRAN: I do not know whether you could explain the great increase that has occurred in the item of depreciation on stores and cable in stock. I find, on looking back to the previous three half-years, that you have charged for that item £323, £313, and £219, whereas this half-year it has suddenly sprung up to £734, which is a very considerable advance. I did not quite catch what the Chairman said as to the £100,000, and about adding £22,000 to the reserve fund. I suppose those are the accumulated payments for the new cable.

The CHAIRMAN: No, you did not understand me. We have now a reserve fund of £78,000, after having spent more than £22,000 on the new cable. If that money had not been laid out upon the new cable our reserve fund would be £100,000.

Mr. COCHRAN: That is practically what I understood. It strikes me as rather a severe tax on our revenue that something like £8,000 should be written off in one half-year for really capital charges. We have paid half of the annual payment on account of the Cienfuegos-Santiago cable, £1,875, cable repairs, £3,698, and we carry to the reserve fund £2,656, making altogether £8,229 for the half-year, while the distribution to the shareholders is only £9,400. I have always felt that it is a wise thing to maintain the Company in a sound financial position, but at the same time I think that is rather a severe docking of our profits, unless it makes the future more secure, but I do not know that I am prepared to do more than simply draw attention to it. It seems to be rather a heavy sum to deduct from the gross profits.

Mr. W. GRIFFITH: I rather agree with the last speaker that the reserve fund is a very fine figure. I am in favour of safety and of everything that is necessary to secure the future welfare of the Company; but as we are fortunately paying a rent for one of our cables we do not need a reserve fund so strongly as other companies do. Other companies buy their cables and are unable to ensure themselves against any risk to them, and it is a point with them to have their reserve fund standing at a large figure, even though the interest earned by them is small. We have the additional security of, however, renting our cable, and the insurance of it is included in the rent. That is a question of policy which requires consideration. I would, like my brother shareholder, merely suggest that the reserve fund be kept down, and that, if possible, the dividend should be increased. That may be a selfish policy to some extent, but I think it may also be a safe policy. I must apologise for being a little late, and the question which I am going to ask may already have been answered. Have we anything to fear from the new line from Halifax to our neighbourhood? I suppose not, but you are able to tell us more surely about the future than we can guess it. Reading over the report, I was sorry to see that our old friend, Mr. Horatio Perry, had died. He was a gentleman who had served us extremely well in that very warm climate, which I found was too warm to be pleasant, although I have travelled over the south of Europe. I am sure that we ought to be very thankful to him for what he did for us.

The CHAIRMAN: Replying to the remarks of the two previous speakers, the stock of our material is always valued by our engineer, and we get his certificate at the end of every year. We have had it this year. The whole of the stock has been overhauled, and a revaluation has been made. This has caused, perhaps, some little increase in the charge for depreciation of the stock. Still, the stock is there, whether we value it at a larger or a smaller amount, and it stands in our books now at, perhaps, a lower value than it is; but it is better to err on the safe side and write off so as to keep down our assets to their true value. The figures quoted are, no doubt, quite accurate. We have charged our revenue with a large sum in the half-year, but that is mainly because the repairs have been done in the half-year. All repairs must be borne by the revenue in the half-year. There is nothing outstanding. The rent of the one line which we have taken from our manufacturers has hitherto been charged against revenue. I do not think there is any necessity for altering that. It had to be paid for 12 years, and as we have paid it for 10 years the line will be ours in two years more without paying any further rent. After that time we shall have to pay for the repair of it. During the period of the rent the cost of repairs have been paid, not by us, but by the contractors. I do not think it is wise to increase the dividend under present circumstances. We have before us, as you know, the possibility of opposition, which may materially reduce our receipts. I hope the dividend will never go below 8 per cent., but while we maintain it at that rate I think it is a highly satisfactory return, especially if we can sustain it and yet put something more to reserve fund than we should do but for the fact of the threatened opposition. I hope that if the opposition goes off we shall be able to increase the dividend, but if we can sustain it at 8 per cent I think the shareholders generally may feel that it is a satisfactory result. As to the threatened opposition *vid* Halifax, the line has been made from Halifax to Bermuda, but we have heard nothing of its being extended beyond Bermuda. He then put the motion to the vote in the usual way, and declared it carried unanimously. Continuing, he said: The next resolution is:—

"*That the following dividends for the half-year be now declared upon the shares of the Company, viz., at the rate of 10 per cent. per annum, subject to income-tax, on the preference shares, and 8 per cent. per annum, free of income-tax, on the ordinary shares, payable on and after to-morrow.*"

Mr. CHARLES W. PARISH: I beg to second that.

The CHAIRMAN put the motion in the usual way, and it was carried unanimously, adding: It falls now to someone else to propose the next resolution.

Mr. LOW: I have much pleasure in proposing:—

"*That Mr. Thomas Greenwood be re-elected a Director of the Company.*"

Mr. JAMES GODDARD: May I have the pleasure of seconding that? I think our business has been carried on in the most prudent manner, and I quite agree with the Board in thinking that, while anything threatens us, it will be best to go on as we have done, making the reserve fund as large as we can, and writing off everything that we can.

The resolution was carried unanimously.

The CHAIRMAN: I thank you for re-electing me to my seat on the Board. I shall be pleased to do all that I can in the interests of the Company, and therefore in my own interests as one of the members of it. The next resolution must also come from the other side of the table.

Mr. HOOPER: I am sure that our accounts are presented to us in the way we should desire in every respect, and therefore I propose:—

"*That Mr. John Gane be re-elected auditor of the Company for the current year at a salary of 20 guineas.*"

Mr. BAYLES: I second the motion.

Mr. GRIFFITH: Is there any plan by which we should be able to have our accounts audited if Mr. Gane should unfortunately be taken to a better world? We were in that difficulty before, and I then suggested the advisability of a second auditor. I still retain that view.

The CHAIRMAN: We have had that question discussed at several meetings. The Board made a proposal to the effect that in the event of the death of the auditor occurring in the half-year the Board might appoint an auditor for that particular half-year; but the meeting did not approve this suggestion, and the Board did not wish to press it. As Mr. Gane is a young man and in good health I do not anticipate any difficulty occurring on this score. He

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then put the resolution to the meeting, and it was unanimously adopted, adding: I thank you for your attendance; the business is done.

Mr. HOOPER: May I propose a special vote of thanks to Mr. Keith for the work which he has done in the past half-year? I have seen Mr. Keith, and I feel that as long as you have him as your engineer you may be sure that anything that can be done for you at Cuba will be done. At the same time the shareholders must remember that they are dependent on two deep sea cables, one laid in 1875 and the other in 1881, the latter being manufactured as early as 1874. That was put down at the risk of the contractors, who agreed to maintain it for 12 years. That cable has fortunately stood well, and the interruption to it has been made good, but it was due to Mr. Keith that it was made good, and he not only repaired the 1881 cable but also the cable laid in 1875, and the cable between Cienfuegos and Batabano. I have been out there, and it will be satisfactory to you to know, with regard to those photographs on the wall, that the works are in first-rate order. I was surprised to see what work could be done at that workshop. You see cable there that has been recovered from the water, and it is utilised over again. The engines, boilers, and apparatus which Mr. Keith has out there are in very good order, and are well worth the money shown in the balance-sheet, and the staff out there seemed to use their best endeavours to repair the interruption to the two cables which occurred last February. Speaking as a shareholder, I think that our thanks are due to the staff in Cuba for their work in the past six months. I only say what I feel myself, and I propose a vote of thanks to Mr. Keith and the staff in Cuba.

The CHAIRMAN: I am pleased that Mr. Hooper has spontaneously risen to speak in favour of Mr. Keith and his work. No one is better able than Mr. Hooper to speak on this subject. He was out there during the laying of the new cable and the repair of the old one. Mr. Keith has done his work well and at a moderate expense, and his whole time and attention are given to the work in the Company. He has also given his skill, which is very great. He is fully acquainted with the whole of our business there, and he has not only a knowledge of the business, but also of the language, which is a great desideratum. I should like to second the motion of Mr. Hooper, both on behalf of myself and the other members of the Board. The motion is that a vote of thanks be accorded to Mr. Keith and his staff for the work which they have done for us in the past half-year, which has been satisfactory to the shareholders and the Directors.

The resolution was carried unanimously.

Mr. COCHRAN: We do not usually separate without formally expressing the appreciation of those on this side of the table at the management of our affairs by the Directors. I am sure that while we all agree that a very large amount of our success must rest with the officials on the other side—and we all heartily concur in the observations made by Mr. Hooper—we also remember that some portion of our success must depend on the way in which the business is managed here. I, therefore, rise to propose a hearty vote of thanks to the Chairman and the Directors.

Mr. GRIFFITH: I have very much pleasure in seconding that. The proposal is certainly a reasonable one, and Mr. Hooper's proposal was most reasonable, and would commend itself to all right-minded persons, more especially as we have such valuable and incontrovertible testimony as to the value rendered to us by Mr. Keith. While, however, we properly render our thanks to those abroad, it is only right that we should acknowledge the services of the gentlemen on this side. I, therefore, have great pleasure in seconding the resolution.

The motion was carried unanimously.

The CHAIRMAN: It is very kind of you to think of us in this very agreeable manner. The Board very much appreciate your goodwill. I can assure you that we are doing our very best to promote the welfare of the Company. There are little difficulties that crop up which the Board have to deal with, and which have a large bearing on the question of the success of the Company. Hitherto we have succeeded in our dealing with these little difficulties, and I hope that we shall continue to do so.

The proceedings then terminated.

Montevidean and Brazilian Telegraph Company (Limited).

A general meeting of the members of the above-named Company was held at the office, Langthorn House, Copthall avenue, E.C, on Tuesday, August 11th, for the purpose of an account being submitted showing the manner in which the winding-up had been conducted. Colonel H. G. W. Macaulay presided.

The Liquidator's report presented to the meeting showed "The number of shares in the Western and Brazilian Telegraph Company (Limited), issued as the consideration for the purchase of the undertaking of the Montevidean Company, was 5,300, as stated in the Directors' circular of November 11, 1890. These shares were distributed as follows, in accordance with the special resolutions confirmed on December 10, 1890:—

To shareholders in the Montevidean Company	4,343
To debenture-holders in the Montevidean Company	650
To the liquidator, in satisfaction of his remuneration	10
To the Directors and secretary, as compensation for the loss of their offices	145
	5,148
Unappropriated balance, to be sold and proceeds applied towards the expenses of the liquidation	152
	5,300"

The financial position was stated as follows:—"As shown in the cash account, the unappropriated shares have been sold at £10. 17s. 6d. per share, the proceeds amounting to £1,653. The expenses of the liquidation, amounting to £164. 16s. 5d., have to be paid out of the proceeds of the above-mentioned shares, together with an amount of £380 for the redemption of debentures not previously charged to the Company's revenue account. As shown in the cash account the balance will allow of the payment of a first and final dividend of 2s. 5d. per share to the holders of all shares, whether preferred or deferred, in the Montevidean Company, amounting in all to £1,050. 12s. 11d., and leave the sum of £26. 9s. 5d. still unappropriated."

The CHAIRMAN stated that since the circular of Mr. George Fraser the liquidator, had been issued, the Stock Exchange had granted a quotation for the above shares. A large number of shareholders had sent in their proxies approving of the scheme. He paid a tribute of praise to Mr. George Fraser for the manner in which the liquidation had been carried out, and concluded by moving—

"That the liquidator's report and cash account, now submitted to the meeting, be approved and adopted."

The motion was seconded and carried.

A vote of thanks was accorded to the liquidator (Mr. George Fraser) for the manner in which he had carried out the liquidation of the Company; and a vote of thanks to the Chairman for presiding terminated the meeting.

United River Plate Telephone Company (Limited).

The fifth annual ordinary general meeting of this Company was held at Winchester House, 50, Old Broad-street, London, E.C., on Friday, August 7, 1891, for the purpose of receiving and adopting the report of the Directors and the accounts for the year ending March 31, 1891; and for transacting the ordinary business of the Company; Mr. J. Irving Courtenay, the Chairman of the Company, presided.

Mr. ROBERT HERRING (the Secretary) read the notice calling the meeting, and the report of the Directors was taken as read.

The CHAIRMAN said: Gentlemen, I rise to move the adoption of the Directors' report and statement of accounts. When I last had the pleasure of addressing you, now 12 months ago, I certainly did look for an improvement in River Plate affairs, but very shortly after the last meeting a revolution broke out in the Argentine Republic, and from that day to this it cannot be said that there has been any improvement financially; on the contrary, the gold premium has fluctuated violently, and the recent unfortunate failure of the English Bank of the River Plate has caused, if possible, an increased want of confidence on this side. The failure of that bank had no effect upon this Company directly, as it was not one of our bankers. By the direction of the Board an account which we had with its Rosario branch was transferred nearly a year ago to the London and River Plate Bank. I am aware that it is the opinion of many that matters have reached their worst, and there are undoubtedly some hopeful features in the situation, but the position changes so rapidly that I think it the wisest course not to attempt to give any strong opinion as to the probable course of events in the near future in the Argentine Republic. Regarding the results of the past year's working in our own Company, they have been entirely governed by one factor, namely, the gold premium, to which I will call your attention later on. The gross income for the past financial year was £106,259. 19s. 8d., as compared with £108,612. 2s. 7d. in the previous year. The difference arises solely from the diminution of our sales business, which, in consideration of the long credits customary in the River Plate, we have not thought it prudent to push. I desire to call your particular attention to the strength of the Company's business, notwithstanding the continued crisis, as shown by the figures I have just given. There has actually been more money received from subscribers and messages this year than was received last year, though there has been a considerable falling off in the total number of subscribers. We have had no less than 1,099 new subscribers come on our books during the past year, and I believe we shall find our experience to be the same as has been found in other enterprises, that the subscribers who come on during a period of financial tightness are more permanent subscribers and are better payers than those who come on during a period of inflated commercial prosperity. You must understand that there is no diminution in the demand expressed for telephonic communication, but our representatives are very wisely prompt in taking out telephones from bad payers. Our working expenses in the Plate were £56,941. 1s. 9d., against £63,497. 15s. 5d. for the previous year. This reduction of £6,556. 13s. 8d., being over 10 per cent., has been the result of economies made where practicable, notwithstanding the increased cost, to a considerable extent, of materials, general expenses, and taxes. The Directors have endeavoured to effect all economies possible in the management and expenses of the Company, and in this they have been effectively aided by our managers in the River Plate. Further economies, to some extent, are anticipated, but unless a reduction in the gold premium occurs a greater degree of expenditure must be expected; this would necessitate such a rise in our rates as would at least meet the increased expenditure. The capital outlay for the year has been £3,096. 10s. 10d., against £12,772. 8s. for the previous year, and though this figure is low, still a considerable amount of important work has been done which has been charged to revenue, such as a complete installation of lightning arrestors, which will prevent serious damage to our whole plant, including the multiple switch-board at the central offices, not only from lightning, but from contact with electric light wires. We have also pulled down old lines of the two old Companies, and have built several miles of new trunk lines, thereby reducing taxes on posts and expenses of working and maintenance. Our Buenos Ayres manager reports that our plant to-day is in a most excellent condition in every respect, and that its working is perfect; and from our other important centre, Rosario, the manager writes—"It is a great pleasure to me to be able to inform the

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Board that the service, I am sure, cannot be beaten in any part of the world; complaints there are none." We had the advantage of a personal inspection by one of our Directors, Mr. Cooper, during last spring, who, on returning to this country, gave a most satisfactory report both as to the efficiency of the service and the general management of the business. The Directors, mindful of the necessity for diminishing expenditure in all directions, have, as stated in the report, reduced the London fixed expenses since the end of the financial year by one-third, so that these expenses now stand at about one-half of what they were for the previous year, *i.e.*, the year ended March 31, 1890. I have now, I think, touched upon most of the points in the Directors' report and the figures in the balance-sheet, and I can but express my great regret that we are unable, for the first time in the history of the Company, to declare a dividend. This is entirely owing to the loss on exchange, amounting to £36,049. 0s. 8d., or nearly 12½ per cent. on the Company's paid-up share capital, a loss, of course, wholly beyond our control. In spite of the extremely adverse circumstances we have had to contend with in the River Plate, and of which you are fully cognisant, the business of the Company has held its own remarkably well and shows an undoubted vitality; so that it may reasonably be expected that with only a slight revival of commercial affairs in Buenos Ayres and a fall in the gold premium, the Company would soon again be in a dividend paying condition. I may properly mention here that the latest telegraphic advices from Buenos Ayres, dated the 4th inst., state that our receipts for July are better than for the same month of last year, which cannot be regarded as other than satisfactory. Several changes have taken place during the past year in the administration of the Company. We have met a severe loss in the death of our colleague, Mr. John Coghlan, a gentleman widely and most favourably known in connection with River Plate affairs for very many years. Lord Thurlow, who was with us from the beginning, as our Chairman, felt obliged owing to the pressure of his other engagements, to tender his resignation as a Director, which the Board very regretfully accepted. Our late Secretary, Mr. Unwin, who has also been with us from the outset, resigned his post at the end of the year to enter into partnership with an old-established South American firm. The Board, desiring to retain the benefit of his valued services and long business experience in South American business, elected him to the vacancy caused by the death of Mr. Coghlan. It also appointed to the vacant secretaryship, Mr. Robert Herring, who has always been the Company's accountant, and who now unites the duties of both positions. Feeling the necessity of a more general supervision of the Company's affairs under this re-arrangement of the home management than could well be given by an ordinary Director, the Board have thought it wise to ask Mr. Frank W. Jones, one of its members, to take the position of Managing Director, which I am pleased to state was accepted by him. Mr. Jones, who is here to-day, and who is one of our largest share and debenture holders, was, as you will remember, Chairman and Managing Director of one of the enterprises in the River Plate upon which this Company was founded. I shall conclude my remarks—and shall be happy to give any further information that I can—by moving the resolution:—

"*That the report and accounts submitted to the meeting be, and they are hereby, received and adopted by the Company.*"

Mr. GEORGE COOPER: I beg to second it.

Dr. ELLIS: The speech of the Chairman has covered so much ground, and has covered it so very satisfactorily, that it leaves very few words for me to say, further than to ask one or two questions more or less for my own personal information than for anything else, and first of all I should like to inquire when the exchange—or rather the premium—on gold fluctuates from 200 to 300 per cent., how it is that the very large sum of £36,000, mentioned in your speech, is lost to bring home £38,000? I cannot understand how this is. That is one question I should like answered, and this is another: Whether it is necessary, when the exchange is so very adverse, to turn all our paper money which we receive into gold at once? I want to know whether it would not be better to keep a certain portion of it, at all events, out in the Bank at the River Plate and in Buenos Ayres against better times. Of course these are technical matters which I have no doubt can be satisfactorily answered; still, I should like to know. Then there is one other subject mentioned in your speech, that of extensions, and it is stated that a further £3,000 has been spent upon extensions. That has gone to capital expenditure, I suppose. I should like a little explanation upon that point. There is one other matter, too, to which I would like to refer, which is that all the figures and details in the accounts are given in pounds sterling. I know that it would be difficult, if not impossible, to mix pounds and dollars, but at the same time it is a little misleading. It seems that we have gone into a further £3,000 expenditure in the River Plate, and I want to know whether that really means £3,000, or whether, under present conditions of exchange, it does not mean about £15,000 or £20,000 in River Plate money.

The CHAIRMAN: I am sorry to say that I cannot quite see your point.

Dr. ELLIS: I want to know whether the £3,000 expended means £3,000 sterling; I mean the additional working outlay in the River Plate, because if it is not in sterling it becomes a very serious matter, and means a very large sum of money out there in paper, and shows the extreme necessity for avoiding any increase of capital expenditure at the present time, because 1,000 new subscribers would hardly pay for the expenditure of £3,000 sterling.

The CHAIRMAN: It is in sterling.

Dr. ELLIS: Well, with these few questions, to which I shall be glad to have answers, I need say nothing more except that I never heard a more satisfactory speech in many respects, and in regard to the explanations given to the shareholders, than has been given by yourself, sir, to-day. It has been a most exhaustive statement and as satisfactory a speech as any one that I have listened to that has not had for its termination the declaration of a dividend.

The CHAIRMAN: If there are no other questions to be asked I will rise to answer those of the hon. proprietor, Dr. Ellis, and he must first of all permit me to say how much I thank him for the kind expressions he has used with regard to the explanations given in my speech. The whole subject is a question—as I stated in my speech—of exchange, and we, as a Company doing business in that country, have auditors who have to pass these accounts, and, in order that they may be duly checked and audited, the money must be converted into sterling. We should be very glad indeed to avoid this if we could, but there is no help for it. We cannot present our accounts in paper dollars, and we are compelled to convert. The same question has occurred to us as has occurred to Dr. Ellis, whether, instead of converting our money into pounds sterling, we should leave the money there, as suggested, at some of the banks, and not convert it. Well, the first objection to that is that we want the money here to pay our debenture interest, and we have to bring the money over to pay the debenture-holders in sterling, and therefore we must convert; and then, again, you will observe that we should run a very serious risk if we did not convert our money, but left it there in the banks. That amounts to speculation upon the gold premium, because if it rose we should stand to lose, and if it fell to gain. Now, if we had not converted and brought over this money, which we have done, and if we had let it wait there in hopes of better times, and it had become necessary to bring over a large amount at the present time, we should have incurred a considerable and serious further loss. It is a policy pursued by other companies in the River Plate, and, after careful consideration, it is believed to be the wise one to convert the money at the rate of the day from time to time when necessary to bring it over, and not to speculate upon the probabilities of the rise or the fall which may take place in the gold premium, and which might lead to a very serious loss. Therefore we have adopted this policy, and we think that it is a very sound policy, and, as I said, we have the satisfaction of knowing that this policy is adopted by other Boards of Directors having heavy business interests with the River Plate. We have carefully considered the matter, as they have, and we have all arrived at the conclusion that it is the right policy to adopt. Now, with regard to the other point to which the honourable shareholder addressed his observations, viz., the question of the expenditure of £3,000 in the River Plate. You must remember that a large proportion of that was for materials. These materials are telephones and other things that are bought here (in London) and paid for in gold. Wages and other things over there are paid for in paper; therefore it does not represent the very large sum which you think, because a large portion, at any rate, as far as the bulk of the materials are concerned, have been bought here and paid for in sterling here.

Colonel ARMSTRONG: May I ask how much money has to be sent here from the River Plate?

The CHAIRMAN: We have had sent over here sufficient to pay the debenture interest and for the expenses of carrying on the Company.

Colonel ARMSTRONG: I suppose that amounts to about £9,000?

The CHAIRMAN: You will see it here in the figures.

Colonel ARMSTRONG: We seem to convert according to the accounts at a cost of £36,000 to send the money here.

The CHAIRMAN: We have no choice—we have to convert.

Colonel ARMSTRONG: The wages and other payments, I suppose, are made in paper there, and this is the cost for the conversion of the money sent home?

The CHAIRMAN: You may put it, if you like, as the cost of conversion there.

A SHAREHOLDER said that he did not understand the way in which the conversion was carried out, and he wanted to know whether the accounts showed that the whole of the money—every farthing of revenue that had been earned in the River Plate—had been sent over here.

The CHAIRMAN: All the surplus has been sent home.

The SHAREHOLDER: The surplus is what I mean.

The CHAIRMAN: Yes.

Dr. ELLIS: I do not quite understand yet how it is that the large sum of £36,000 is charged to send home £38,000.

Mr. J. OWEN UNWIN, a member of the Board (at the request of the Chairman), replied to the question, and said that he must admit that this question of exchange was a most puzzling thing for anybody to understand, but the Directors could assure the shareholders that there was no doubt that the accounts, as presented, were perfectly straightforward, but he would endeavour in one word to make the matter clear. They were dealing in a country with the depreciated paper currency, but the capital of this Company was raised in sterling, and their debenture interest was paid in sterling, and their dividends, when they came, were paid in sterling. They transmitted their capital, which was subscribed, out to the River Plate, and they had to deal with it in the currency of the country. Perhaps most of the shareholders were aware that when they took their capital out to the River Plate the exchange there, or rather the premium on gold, was very much lower than it was at the present time. In fact, when the Company was started, the premium on gold was something like, he believed, 30 per cent.

The CHAIRMAN: Yes.

Mr. UNWIN said that when they came to make up their accounts they had to convert the paper into sterling at the exchange of the day—the rate then ruling—and they must do this in order to avoid speculating. When their money was taken out it was, of course, what was then known as the "par of exchange," but that had long since wandered away, for the condition of things was entirely altered, and £106,000 in paper money was only really worth something like £40,000 or £45,000 in sterling. It did not matter what they dealt in—be it as a manufacturing company, be it as a railway company, be it as a gas company, be it as a telephone company, or be it as a merchant—if they were trading in a country with a depreciated currency, and their head-quarters were over here in England, they must convert their paper money into sterling at the exchange of the day. If they liked to leave their paper money over there—for instance, if this

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Board of Directors liked to leave any surplus in the River Plate—they would have to borrow money against it on this side, and by leaving their paper money over there they would be "simply and solely speculating upon the rise or fall of the exchange." If it went up they would be losing money, and if it went down they would get more—it was simply a matter of speculation.

Dr. ELLIS: Excuse me interrupting you, but I do not think that you see the point. What I want to know is, how we could have lost £36,000 to bring home £38,000 at the present rate of the gold premium.

The CHAIRMAN: It is on the working for the year.

Dr. ELLIS: I thought it was on £38,000.

The CHAIRMAN: It is on the total transactions of the Company.

Mr. FRANK W. JONES: It is not upon £9,000 sent home.

Colonel ARMSTRONG asked further questions in regard to the same matter.

The CHAIRMAN stated that, as had already been explained, the matter was quite correct, and the accounts were duly audited.

Mr. FRANK W. JONES said he wished it to be clearly understood that the loss in consequence of the premium, as shown by the accounts, was not upon £9,000 nor upon £38,000, but was upon the entire working of the Company, and which had to be converted into sterling at the current rate of exchange of the day upon which the money was transmitted.

The CHAIRMAN: I will now put the resolution. It has already been read to the meeting. Those in favour of the same will signify it in the usual way, by holding up their hands. Against it. That is carried unanimously. The next business is the re-election of Directors.

Mr. FRANK W. JONES: I beg to propose that Mr. J. Irving Courtenay be, and he is hereby, re-elected a Director of the Company.

Dr. RAE: I beg to second it.

The resolution was unanimously carried.

Mr. FREDERICK GREEN: I beg to propose that Mr. J. Owen Unwin be, and he is hereby, re-elected a Director of the Company.

Mr. BILLETER: I beg to second the motion.

The resolution was carried.

The CHAIRMAN: The next business is the re-appointment of auditors, Messrs. Cooper Brothers and Co. It is a shareholders' question, and I will ask a shareholder to propose it.

Mr. RODGERS: I beg to propose that Messrs. Cooper Brothers and Co. be, and they are hereby, re-elected auditors of the Company for the current year.

Mr. EDWARD PINCHES: I have much pleasure in seconding the motion; it would be impossible to have more efficient auditors.

The motion was carried.

The CHAIRMAN: That concludes the business of the meeting.

Dr. RAE: I beg to propose a vote of thanks to be passed to the Chairman for the way in which he has conducted the affairs of the meeting to-day, and I agree with the gentleman who spoke earlier (Dr. Ellis) that I never heard a more clear and pleasant statement from a Chairman over a bad business than that which he has made to us to-day. He has put everything clearly before us in a wonderful manner. I did not myself quite understand the £36,000 cost of bringing money over—loss on exchange—but I begin to see how it is now. I have much pleasure in proposing the vote of thanks.

Dr. ELLIS seconded the motion, which was carried amid applause.

The CHAIRMAN, in reply, said: Dr. Rae and gentlemen,—I sincerely thank you for the very kind vote of confidence in myself, which I take also to be a vote of confidence in my colleagues. You will quite understand we have had a very anxious time during the past year—it has been a very anxious time for anyone connected with River Plate affairs—and all I can say is that I trust that the next time we meet you we shall have some of the dark clouds dispelled. I thank you for your attendance here to day, and for your vote of thanks.

The proceedings then terminated.

City and South London Railway Company.

The fourteenth ordinary general meeting of this Company was held at Winchester House, Old Broad-street, on Tuesday, under the presidency of Mr. Charles Grey Mott.

The SECRETARY (Mr. W. F. Knight) read the notice convening the meeting, and the report of the Directors was taken as read.

The CHAIRMAN: It now becomes my duty to propose:—

"*That the report and statement of accounts for the half-year ended June* 30, 1891, *now submitted to the meeting be approved and adopted.*"

There is one matter connected with this report which I am sure you will have read with satisfaction, and that is that we have been enabled to carry over the line 2½ millions of passengers during the half-year without any accident whatever. I regret that a few days ago, for the first time in the history of the Company, a fatal accident occurred connected with the line, but as the passenger in that case acted in violation of the bye-laws of the Company, and in direct defiance of the officers of the Company who were carrying out those bye-laws, no blame could attach to the Company itself at all. At the same time you may be sure that we exceedingly regret such an accident, and that we sympathise very much with the relatives of the passenger. The past half-year has, as you can well imagine, been a very anxious one for the Board. In the first working of a new system, such as this, three points are naturally presented to the Directors: first, will the system of electric locomotion which we have adopted work at all? secondly, will it work satisfactorily? and, thirdly, will it work in such a way as to give a remunerative return to the shareholders for the money invested? On the first two heads we can report with confidence in the affirmative. We have worked the railway, and we have worked it satisfactorily. As regards the last head, I am sorry to say that at the present moment we cannot answer it with the same satisfaction as we can the two first. We have yet to show that this system is not only efficient, but also that it is one that will be a thorough financial success. As you have seen from the accounts, the past half-year has given us a profit which has enabled us to pay our debenture interest in full, leaving a very slight margin beyond. As we have no other preference charge at the present moment beyond our debenture interest, and beyond the very small sum that we may have to pay for the preference shares that may be issued—which is not a large amount, as you know, but very small indeed—any further profits on this line will go into the hands of the ordinary shareholders. I hope that our future profits will go on steadily increasing, and that it will not be very long before I may have the pleasure of standing here and feeling that we have earned a substantial dividend. But that rests with the future, and I do not like to prophesy—you know that I have always refused to do so, and wisely, I think. I prefer to deal with accomplished facts. Now, you may like to have a short *résumé* of our present position, financially. Our receipts from passengers during the past half-year—and they are the only source of receipts we have at the present moment, because we have practically no other traffic over the line but passenger traffic—have amounted in the whole to £19,403. We have received a small sum for transfer fees, rent of property, &c., bringing the total revenue for the half-year up to £19,637. We have received this by carrying 2,412,343 passengers. The number of passengers per train mile we have run is 17. If this were an ordinary railway that would be a very large number, because the general average of the large English railways is only about 3½ passengers per train mile. The general average of all the railways—including the suburban lines—in this country is about five passengers per train mile. As I have said, we have carried 17, but then, ours is purely a Metropolitan line, costing very much more, and the traffic upon it is expected to be very much heavier than the ordinary railways of the country. Now, you may say, Is your capacity for carrying the traffic at its maximum? No, with our existing train service we could carry three times the present number of passengers if we had them to convey spread over the whole of the 24 hours. Therefore, we have capabilities of development even in our present system of working—with the present number of trains we run. We propose, however, and hope before long to be running more trains, and if the traffic goes on, as we hope, steadily, we shall be able to take a very much larger number of passengers than even our full capacity now may be. Our earnings per train mile have been 2s. 9d. Of course, the earnings per train mile on a line of this kind ought to be larger than on an ordinary railway. Unfortunately, however, that is not at present the case, because we are not carrying the relative traffic to those railways that we ought to carry. The average receipts from passengers, pure and simple, apart from parcels and mails, carried by passenger trains on a line like the North-Western are 3s. 3d. per train mile against our 2s. 5d. Some of the railways, of course, earn more than 3s. 3d., and all the large railways benefit, of course, by the receipts which they get from other things which are carried by passenger trains—for instance, parcels, horses, carriages, mails, and things of that description. As regards our expenses, they have been, as stated in our report, heavier in the past half-year than the rate at which we are now working. In the early stages it was necessary that we should have a very large staff to deal with a traffic which was unknown and new, and we also had to have expensive men to educate the staff on a new system of this character. A considerable reduction has been made in the expenditure, and we are now working at a much less rate than we were in the early days of the concern. That, of course, is one of the pleasant features in the future. We have, of course, yet to learn what the cost of maintenance of our stock will be. It is all new now. I do not think it is likely to turn out that we shall have a very heavy item for maintenance. In our experience so far our permanent-way expenses are not likely to be as great as those of ordinary railways. Our locomotive power is the one point which, at the present moment, compares unfavourably with the ordinary working of a steam railway; but I would venture to caution you against taking the amount which at present appears in our accounts under "locomotive and generating power" as a permanent and absolutely ascertained figure. It has been difficult, especially in the early part of the half-year, to distinguish what was the permanent charge in that respect, because our motive power is used for various other purposes besides that of working the locomotive power itself, and the absolute division between these two in the half-year is not an ascertained fact. In future we hope to have it an ascertained rather than an estimated fact, and we shall deal more accurately with these matters in future half-years than we can do now. The expense of running has been about 11d. per train mile in the present accounts. That compares with charges on an ordinary railway, varying from 9½d. to 1s., so that we may be said to be not far from on a par in the past half-year with the ordinary charge per train mile of an ordinary steam railway; but, of course, our trains are very much lighter, and will not carry so many passengers as a train on a steam railway. As, however, we carry as many passengers at the present moment as we have to carry (we do not send any away), we are not losing anything by having smaller trains, and I am not sure that in the future the system we shall adopt of running light trains more frequently will not prove more economical and more conducive to the public convenience than running heavier trains, as on an ordinary railway, many of which run comparatively empty. We have had to contend in the past half-year with a good many difficulties. We are trying steadily to overcome them. They are not serious difficulties any of them, but, although small, the improvements which we are making, and hope to make, will, I think, render the railway much more popular when they are carried out than it has been in the past. At the same time, anyone who has used the railway will, I think, feel that as far as comfort, speed, and all the general accessories of convenient railway travelling are concerned our line is really not inferior to that of any of the ordinary steam railways. We hope in

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future to make it very much superior, and I believe that, when all our improvements are carried into effect, it will be confessed that we have brought into use a system of locomotion which will be a decided improvement upon what has hitherto been in existence. The great stage coaches of the past had their day, and were efficient in their day, which lasted for some 60 years. They were superseded by the steam railways, which have had their day, and have lasted up to the present time for another 60 years. It remains to be seen now whether, after all, the time has not arrived when some new departure ought to be made in our locomotion. Whether electricity is the mode and is to be the new departure has, I think, yet to be proved, but we have the satisfaction of knowing that, at all events, we have tried to do something towards the development of an improvement in the future, and I hope it will not only prove a success as regards public convenience, but that the time will come when I shall be able to congratulate you upon its being a financial success also. The improvements which we are making are in various directions. We have had two new trains of carriages built. They are now on the ground and are being put together ready for working, and I think that they will be a decided improvement on the old ones. We have two locomotives building which we also believe will improve the speed and regularity of the trains. The lighing of the trains is having our special attention, and half the trains are now lighted on an improved principle, which, I think, will be still further developed. It is the electric light. Hitherto it has been, as you know the electric lighting very often is, an uncertain matter; I think we are now making it into a certain and fixed light that will be thoroughly satisfactory for the purpose. We have just placed two new boilers in position, so as to give us additional power. We have a new engine and a new dynamo nearly ready for delivery, and before long we shall be in a position to cope with the traffic which comes to us—as, unfortunately, all suburban traffic does come—in an irregular manner, that is to say, in the morning and evening you have a certain crush of people, while in the middle of the day we should be glad of more passengers than we now carry. We hope to get our increase of traffic, first, from disabusing the public mind of the prejudice which exists at present very largely against travelling by an underground railway of this description. When the Metropolitan Railway was first opened, those who recollect it will remember how very strong was the prejudice against travelling underground. People have got over that prejudice, but, with a railway two stories underground and working with a power so little known as electricity, there is, naturally, on the part of the timid section of the public a great deal of prejudice to be overcome. I believe that when we have everything in order we shall overcome that prejudice, and that our traffic will steadily increase. We hope, also, to get—and we are getting, in fact—an increase of traffic from the growth of population on the route. The houses that were formerly unoccupied are now being occupied. New houses are being built in consequence of this line coming in that direction, and, in addition, all railway companies find that increased facility to the traffic produces increased traffic. Therefore, we have every hope that this line, as other railways, will steadily grow in traffic and increase; and as I think our expenses will not grow in the same proportion as they do in the case of an ordinary steam railway, we have, I think, some hope in the future, though, unfortunately, it is hope deferred at the present moment; and I am not able, as I should have liked to do at our first meeting, to declare a dividend. As I have stated at previous meetings one of the most important questions that we have to consider is how to fill up the trains during the middle of the day. We have made an effort to do that in certain cases in the last two or three months by reducing the fare from 2d. to a 1d. from certain stations at stated times. The result has been so far satisfactory. It has resulted in our carrying from those stations already three times the number that we carried before, and our receipts have increased from those stations some 50 per cent. Whether the decrease in the fares at other stations would produce like results is a question that we must consider very carefully. As long as our trains are full at 2d., it is not in the interest of the Company to reduce the fares. We regretted to have to alter the system of a perfectly uniform fare over the whole line, but still, however much you may be attached to a system, we felt that it was our duty in this matter to meet the varying circumstances of the day, and to try and increase the popularity of the line, and, concurrently, its receipts. We agreed to go to Parliament for an extension of this line through the City up to the "Angel" at Islington. That would have been a very good line in itself, and I think would have paid very well, and have brought to the existing line a very considerable increase of traffic exactly at the time we wanted it. Unfortunately circumstances occurred in the first Committee of the House of Commons which led the Committee to throw out the Bill. There was very slight opposition to the Bill itself. The only remaining opposition at last was that of the Corporation of London, and even they, I believe, did not wish or desire that the Bill should have been thrown out. However, circumstances arose in Committee, with which we have nothing to do, which probably induced the Committee to throw out that Bill. I question whether in our present financial position—at least it is very doubtful—we could come to you now with a recommendation for such an extension again. Until we have brought up the price of our shares on the market it might be doubtful if we could issue the capital, except at such a large discount that it would be undesirable to do so. However, between this and Parliament meeting we shall have to consider the question, and if we can see our way of carrying that through, without burdening the existing Company, we should much prefer to do it. The expenses of the Clapham extension remains as a separate item until we can see what is to be done with that matter. The new plant which we are putting down is intended as part of the plant that will work this extension, but the same reason that we do not propose immediately going for the Islington extension again will apply to our carrying out the Clapham extension at the present moment. We propose, however, to do certain things as part of that work which will be available for use on the present line, and which will also form part of the extension traffic in the future. You will see that the action taken by the London County Council (to contest the right of the Company with respect to the line of frontage at Kennington and the Oval stations) ended in our success. It was a very arbitrary action, having no good case as regards ourselves, but really having for its object the testing of particular rights, which they thought they could try with a small company like this with more success than with a larger company. We felt that there was no alternative but to oppose their action, which we did successfully in the first Court, and on their appealing to the Court of Appeal the decision was confirmed in our favour.

Mr. SAMPSON HANBURY seconded the motion.

Mr. S. PETO hoped the Directors would seriously consider before going for any extensions. He thought from what the Chairman had said that it would be hopeless at the present time to raise new capital except on most disadvantageous terms. He saw that Mr. Robinson had resigned his seat at the Board, and that another gentleman had been elected in his place, but with such a small undertaking as theirs was it absolutely necessary to have five Directors. He thought there was no cause for despondency, and of course in such an undertaking they must hope for better things in the future.

The CHAIRMAN, in reply, assured Mr. Peto that the Directors were as anxious as that gentleman himself could be not to commit the Company to any expenditure that could be avoided. He did not think there was any likelihood of their going on with the Islington extension at present. As to the number of Directors, they were bound by the Act of Parliament, and they could not have less than five. Three was to form a quorum, and in the case of illness or absence of a Director, it was almost impossible to get this quorum unless there were five. He quite agreed with Mr. Peto, and was himself not in favour of a large Board, but there must be a sufficient number to make their working certain. Although the income of the Company was at the present moment very small, the work connected with it was not by any means small, and a great deal of constant attention and management was required.

The motion was carried unanimously. A vote of thanks to the Chairman and Directors was then proposed, seconded, and carried unanimously.

The CHAIRMAN, in reply, thanked them for their kind expression of confidence, and assured them that the Directors would do their best to deserve it.

The proceedings then terminated.

Liverpool Overhead Railway Company (Limited).

The half-yearly meeting of the Liverpool Overhead Railway Company was held on Wednesday, at Liverpool, Sir William Forwood in the chair.

The CHAIRMAN, in moving the adoption of the report, said the amount received on capital account was £163,035, of which £143,098 had been expended in works. They had made satisfactory progress during the past half-year. The main structure had been advanced south to the Collingwood Dock, and in the course of the work three important opening bridges had been made, The foundations were completed as far south as St Nicholas Church, and he expected that the structure would be advanced to that point by the end of September, or the beginning of October. During the past two months they had erected two miles of the main structure, and the contractor expects that the whole of the foundation for the southern section will be completed within four months. It was rather difficult to hazard an opinion as to when it would be completed, but he hoped that by next spring they would be within measureable distance of the completion of this important undertaking. During the past six months they had given serious consideration to the means of propulsion to be adopted. The Directors had visited various electrical works in the country, and they had seen the electrical railway now being worked in London. They also had the advantage of the advice of Mr. Greathead, the engineer of the railway passing under the Thames, and after careful consideration they had decided to adopt electricity, because it would be cheaper and safer and cleaner, and more economical in its working than steam. They had invited tenders, and they had selected the one sent in by the Electrical Construction Company, of Wolverhampton, with which they had entered into a contract to work the line for two years at 3½d. per train mile for locomotive expenses. The electricity would be generated at a central station, to be located near the Wellington Dock, a position which they had been fortunate enough to obtain from the Dock Board. By having their station at that point they could obtain water at an advantage, and they would also have the advantage of having their coal tipped from the railway overhead, without the necessity of constructing buildings, &c. In that way they would save a considerable amount of money. The electricity would be conveyed by a central rail to the motor cars which will compose the train, and the journey from end to end, including stoppages, will be made in 25 minutes.

Mr. BRANCKER having seconded the motion for the adoption of the report,

The CHAIRMAN, in reply to questions, said that the 3½d. per train mile covered the whole of what was known as the locomotive expenses of the line. It had been the intention of the Directors from the first to open the northten section as soon as it was completed; but a great deal would depend upon the completion of their electrical plant and generating station. In other words, the southern section was being proceeded with so rapidly that it might be completed by the time the electrical equipment was ready, and in that case all sections of the line would be opened together. The Directors did not at present contemplate manufacturing electricity for illuminating purposes, except for their own uses, and the line would be lit by electricity manufactured by themselves.

The report was unanimously adopted, and a vote of thanks to the Chairman concluded the proceedings.

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Birmingham Central Tramways Company (Limited).

The annual meeting of this Company was held at the Queen's Hotel, Birmingham, on Wednesday, Mr. Joseph Ebbsmith (Chairman) presiding.

The report submitted by the Directors stated that the electric lines, which in the first half of the year were suffering from exceptional difficulties of construction and maintenance, have apparently overcome those difficulties, and show a substantial profit, which is steadily improving. The accompanying accounts showed that the electric car lines, since the opening of the lines on July 24, 1890, had run 138,396 miles, and carried 1,144,718 passengers, the receipts from that department being £8,372. 1s. 8d., against an expenditure of £5,711. 8s. 5d., giving a balance of £3,020. 13s. 3d. The cost per mile run on the four sections of the Company's lines for the year were :—Steam, 10·99d.; electricity, 9·90d.; horse, 9·79d. ; cable, 6·33d. The gross revenue account showed a balance, including £6,124. 7s. brought forward, of £31,782. 3s. 9d., out of which the Directors proposed to place £10,000 to reserve, to pay a dividend of 4 per cent. on the ordinary shares, carrying forward, after payment of the dividend on the Five per Cent. Guaranteed Shares, the sum of £1,262. 3s. 9d.

The CHAIRMAN, having moved the adoption of the report, in the course of his speech, said that that meeting marked an epoch in the history of the Birmingham Central Tramways Company, for to all intents and purposes they had succeeded in carrying out those works of capital commitment which it was the duty of the present Board to accept at the time when they took office four years ago. It was well from time to time to take stock of the progress which was made ; and when they looked back on the dreary record, and when they considered how many of the shareholders and how many experts outside the Company were of opinion that it would not be possible for the Company to meet its engagements, he thought it was very satisfactory indeed to say that every contract to which they were committed at the time when they accepted office had been loyally fulfilled, and that the capital account of the Company was one for the future consideration of the shareholders, and that there were no rocks ahead of which they need take serious notice. The expense of maintenance of the steam engines had increased during the past year by 25 per cent., and almost the same ratio obtained between 1890-89. One cause of this great expenditure was increasing traffic, and it had been necessary that the engines should do an increasing amount of work. That increasing amount of work had meant an increased expenditure in maintenance ; that maintenance must continue, and he could not hold out to them any expectation that the cost of maintenance per engine would decrease. It was an expense which had to be faced, unless, indeed, the shareholders were prepared to recommend the policy of a very great addition indeed to the engine power, so as to enable them to run a proportionately decreased mileage with each engine. But that, to his mind, would not be sound policy. As Central shareholders, they were bound to look forward to the future, and they knew that steam traffic was but a question of time. It was useless to blink the fact that in future another form of traction would very probably obtain. But during the whole tenure of his office he had most scrupulously abstained from anything approaching to prophecy, and he bade them take this comfort home with them—that, having regard to the character of the main lines of the city, and having regard to the accounts of the cable department which were now before them, when the time arrived for the reconstruction of the form of traction haulage of the Company the present shareholders need not fear or doubt their own position. He did not advocate any rash or sudden change. They had had a period of strain in the past ; they asked for the consideration of the local authority and those in power during the period of rest and experiment, and during which they might obtain something like certainty with regard to the results of working any other systems. Whenever it did come it would be, in his opinion, an advance from solidity of position to prosperity, and not a case of injury to the ordinary shareholder by reason of the transformation.

In the course of the discussion which followed, the CHAIRMAN mentioned that the cost of the electric tramway in Bristol-road was, roughly speaking, about £30,000, whilst the cost of the cable lines was 50 or 60 per cent. more than this amount ; this was the cost of construction, but the question of working—a more intricate subject—must be borne in mind.

The Directors' report and recommendations were unanimously adopted, and Mr. Ebbsmith and Mr. Martin J. Smith, the retiring Directors, were re elected.

Johannesburg Gas Company (Limited).

The adjourned extraordinary general meeting of the shareholders of this Company was held, on Wednesday, at the Cannon-street Hotel, Mr. W. F. Lance presiding.

The CHAIRMAN proposed a resolution dissolving the Company, and forming a new company, to be called the Johannesburg Lighting Company (Limited) (which was given *in extenso* in our issue of July 17th), and said that this resolution was agreed to at a meeting on 15th July, but on account of the Directors having an insufficient number of proxies they were unable to declare it legally carried. They had now more than the requisite proxies, the shares represented numbering over 90,000, out of a total of 130.000. He wished to point out that although the total capital was mentioned as £250,000, the Directors hoped to keep it down to not more than £200,000, and to say that although, in consequence of people being out of town, the arrangements for carrying out the proposal set forth in the resolution had not yet been completed, he hoped they would be by October, to which month he would suggest that the meeting be further adjourned, in case of any unforeseen contingency arising.

The resolution was seconded by Mr. PARKER and carried unanimously, and the meeting was then adjourned until Thursday, 15th October

NEW COMPANIES, STATUTORY RETURNS &c.

ENDURANCE SEAMLESS TUBE AND VIAL COMPANY (LIMITED).—This Company has been registered by Waterlow Brothers and Layton (Limited), with a capital of £25,000 in £5 shares. Object : To carry on business as manufacturers of and dealers in weldless and other tubes. The first subscribers are :—A. Chamberlain, Birmingham ; G. Hookham, Birmingham ; P. Hookham, Birmingham ; W. Chamberlain, Birmingham ; J. Harrison, Handsworth ; J. A. Harrison, Handsworth ; H. Lane Edgbaston.

"ENGINEERING" (LIMITED).—This Company was registered on August 7, 1891, with a capital of £180,000, divided into 7,500 Five per Cent. Preference and 10,500 ordinary shares of £10 each, by Hyde, Tandy, Mahon, and Sayer (solicitors to the Company), 33, Ely-place, Holborn, E.C. The objects are : To purchase or otherwise acquire and take over as going concerns the business of proprietors and publishers of the newspaper or journal known as *Engineering*, carried on at Nos. 35 and 36, Bedford-street, Strand, W.C., and also the business of printers and otherwise, carried on at Bedfordbury, St. Martin's-in-the-Fields, under the style of the "Bedford Press."

AKESTER ELECTRO-MOTOR AND ACCUMULATOR COMPANY (LIMITED).—The annual return of this Company, made up to February 28, 1890, was filed on August 5, 1891. The Company, which was registered on May 16, 1887, has a capital of £5,000, in £1 shares ; 5,000 shares have been taken up, upon 1,500 of which 16s. per share has been called, while the remaining 3,500 shares have been considered as fully paid. The calls paid amount to £1,000, and unpaid to £112. The Company's offices have been changed from 50, Holborn-viaduct, E.C., to 36, Great James-street, Bedford-row, W.C. (filed on July 29, 1891).

CHILI TELEPHONE COMPANY (LIMITED).—The annual return of this Company, made up to July 28th, was filed on August 4, 1891. The Company, which was registered on June 28, 1889, has a capital of £250,000 in £5 shares ; 40,000 shares have been taken up, the full amount called and all calls paid. Office : 42, Old Broad-street, E.C.

DEVON AND CORNWALL ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The final order for the winding-up of this Company (which was registered on May 12, 1882, with a nominal capital of £100,000 in £5 shares), upon the application of Alfred A. James, its official liquidator, was granted by Justice Chitty on July 24, 1891, and a notice filed on August 5, 1891.

HEAD, WRIGHTSON, AND COMPANY (LIMITED) (Engineers, Shipbuilders, Electricians, and Contractors).—The annual return of this Company, made up to July 4, 1891, was filed on July 14, 1891. The nominal capital is £210,000, in £5 shares. The Company was registered on June 21, 1891. All the shares have been taken up, and upon 28,001 the full amount has been called and paid, and upon the remainder the full amount has been considered as paid, the calls paid amounting to £140,005, while £69,995 is considered as paid. The total amount for which share warrants, comprising 500 warrants of 1 share each, 200 warrants of 5 shares each, 150 warrants of 10 shares each, and 100 warrants of 20 shares each, amounting to 5,000 shares, are outstanding, is £25,000. Office : Teesdale Iron Works, Stockton-on-Tees.

HOUSE-TO-HOUSE ELECTRIC LIGHT SUPPLY COMPANY (LIMITED).—At an extraordinary general meeting of this Company, held at the Central Electric Lighting Station (Kensington), Richmond-road, S.W., on July 7, 1891, the following special resolution was duly passed, and at a subsequent meeting held on July 24, 1891, duly confirmed :—"That clause 115 of the Articles of Association (which reads as follows :—'Any casual vacancy occurring in the Board of Directors may be filled up by the Board, but any person so chosen shall only retain his office so long as the retiring Director would have retained the same if no vacancy had occurred') be struck out, and the following be substituted :—'The Directors may at any time appoint any qualified person as a Director, either to fill up a casual vacancy, or as an addition to the Board ; but so that the number of Directors shall not at any time be more than the maximum number hereinbefore mentioned, or such reduced number as may from time to time be fixed by the Company in general meeting, provided that any person so appointed shall hold office only until the next ordinary general meeting.'" This notice was filed on August 8, 1891. Office : 117, Bishopsgate-street Within, E.C.

MANCHESTER EDISON SWAN COMPANY (LIMITED).—The annual return of this Company, made up to the 29th July, was filed on August 4, 1891. The Company, which was registered on May 24, 1882, as the "Manchester and District Edison Electric Light Company (Limited)," has now a nominal capital of £550,000, divided into 50,000 "A" shares of £9 each, and 10,000 "B" shares of £10 each ; 20,000 "A" shares have been taken up, and £1 called and paid upon each share, and the whole of the "B" shares have been taken up, and the full amount called and paid, the calls paid amounting to £120,000. Office : 14, St. Ann's-square, Manchester.

LANCASHIRE AND YORKSHIRE ELECTRIC LIGHTING COMPANY (LIMITED).—The annual return of this Company, made up to July 9, 1891, was filed on August 5, 1891. The Company, which was registered on November 4, 1882, has a nominal capital of £100,000 in £5 shares ; 127 shares have been taken up, upon each of which £2. 10s. per share has been called. The calls paid amount to £315, and unpaid to £2. 10s. Office : 6, St. James's-square, Manchester.

NEW TELEPHONE COMPANY (LIMITED).—The following was filed on July 25, 1891 : In the High Court of Justice, Chancery Division, Mr. Justice North. Upon the petition of S. P. Thompson, of the Technical Insti-

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tute, Finsbury, and E. Garcke, of Victoria Works, Belvedere-road, Lambeth, on June 3, 1891. This Court doth order that all further proceedings in relation to the winding up of the Company be stayed. The offices are now situate at 90, Cannon street, E.C. (Filed August 7, 1891).

WILLIAMSON ELECTRICAL AND ENGINEERING COMPANY (LIMITED).—The capital of this Company, which was originally £5,000 in £10 shares, has now been increased to £25,000 by the creation of 2,000 new shares of £10 each, and the notice of such increase filed on July 31, 1891. Office: 14, St. Ann's-square, Manchester.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the weeks ending July 31st and August 7th amounted to £4,251 and £4,243 respectively.

CITY AND SOUTH LONDON RAILWAY COMPANY.—The traffic receipts of this Company for the week ended July 31st amounted to £821.

MANGANESE BRONZE AND BRASS COMPANY (LIMITED).—A meeting of this Company was held on Thursday, at the offices, 73, Lombard-street, E.C., but the proceedings were private.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended August 7th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,680.

WESTERN COUNTIES AND SOUTH WALES TELEPHONE COMPANY. The half-yearly warrants for dividend to June 30th last on the Preference shares of this Company, at the rate of 6 per cent. per annum, were posted on Saturday, the 8th inst.

WOODHOUSE AND RAWSON UNITED (LIMITED).—The Stock Exchange Committee have appointed to-day (Friday) a special settling day in this Company's ordinary shares (Nos. 1 to 31,436) and preference shares (Nos. 40,001 to 59,946 and 61,765 to 61,800), but have refused a quotation in the Official List.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, August 5.	Price Wednesday, August 12.	Rate per Cent. Yielded.	Dividend Due.	Business Done during Week ending August 12. Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
£1,300,980	Stock	12/0	Anglo-American	43 44	43 44	5 5 11	Jan., Apr., July, Oct.	43½	42⅝
£2,849,510	Stock	24/0	Do. Preferred	82 83	82½ 83½	6 14 11	" "	83⅛	82⅛
£2,849,510	Stock	5/0	Do. Deferred	9⅛ 10	9⅛ 10	.. ..	.. ..	10	..
£250,000	100	4%	African Direct, Telegraph 4% Debentures	98 101	99 102	3 19 3	January and July ..	99	..
130,000	£10	5/0	Brazilian Submarine	11⅜ 12⅛	11⅜ 12⅛	6 18 9	Mar., June, Oct., Dec.	12⅛	12
£69,200	£100	5%	Do. 5 per Cent. Bonds	99 102	99 102	4 16 2	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107	103 107	4 13 6	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	105 109	105 109	6 3 10	April and October ..	108	107
16,000	10	8/0	Cuba Submarine	10½ 11½	10½ 11½	6 19 2	February and August	..	..
6,000	10	10%	Do. Preference 10%	17 18	17 18	5 11 1	" "	17⅛	..
12,931	5	3/2⅛	Direct Spanish (£4 paid)	3⅜ 4⅛	3⅜ 4⅛	6 11 10	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9 10	9⅜ 10⅜	5 0 0	" "	10	..
60,710	20	3/6	Direct United States	10⅜ 10⅝	10⅜ 10⅝	6 10 3	Jan., Apr., July, Oct.	10⅛	10 7/16
400,000	10	5/6	Eastern	14⅜ 14⅝	14⅜ 14⅝	4 6 8	" "	14⅛	14⅜
70,000	10	6%	Do. 6 per Cent. Preference	15 15½	15 15⅝	3 17 5	" "	15⅜	15⅛
£1,200,000	Stock	6%	Do. 4 per Cent. Mort. Debenture Stock	106 109	107 110	4 10 11	May and November	107	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	105 108	106 109	3 13 5	February & August	106⅛	..
250,000	10	2/6	Eastern Extension	14⅛ 15	14⅛ 14⅞	4 12 7	Jan., Apr., July, Oct.	15	14⅜
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock	104 107	104 107	3 14 1	February & August	106	..
£85,800	100	5%	Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	102 105	103 106	4 16 2	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	101 104	102 105	4 14 4	" "	..	..
180,237	10	4/6	Globe Telegraph and Trust	9⅜ 9⅞	9⅜ 9⅝	5 5 1	Jan., Apr., July, Oct.	9⅛	9 7/16
180,042	10	6%	Do. 6 per Cent. Preference	14⅞ 15⅛	14⅞ 15⅛	3 18 5	" "	15⅛	14⅜
150,000	10	5/0	Great Northern	18⅞ 18⅞	18⅞ 19	4 10 8	Jan., April, and July	18⅞	..
£229,000	100	5%	Do. 5 per Cent. Debentures, 1883	105 108	106 109	4 12 7	March & September	..	..
17,000	25	37/6	Indo-European	39 41	39 41	4 11 8	May and November	40½	40
38,348	10	5/0	London Platino-Brazilian	6½ 7⅛	6½ 7⅛	6 0 0	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	106 109	107 110	5 10 1	March & September	..	..
9,000	8	4/0	Reuter's	8 8⅛	8 8⅛	4 14 1	April and October..	8 7/16	8
2,381	£100 Cert.	£1	Submarine Cables Trust 6%	115 120	117 121	5 14 9	" "	127⅛	..
15,609	10	6/0	West African Telegraph	8 9	8 9	5 11 1	January and July ..	..	..
£291,400	100	5%	Do. 5 per Cent. Debentures	96 99	96 99	5 1 0	March & September	..	..
30,000	10	2/0	West Coast of America	3 4	2⅜ 3⅜	.. ..	January and July ..	..	..
£150,000	100	8%	Do. Debentures 8% 1902	97 102	97 102	7 16 10	June and December	..	..
88,321	10	9d.	West India and Panama	1⅞ 2⅛	1⅞ 2⅛	.. ..	..	2	1⅛
34,563	10	6%	Do. 6 per Cent. 1st Preference	10 10⅜	10 10⅜	5 14 3	May and November	10⅜	10⅛
4,659	10	6%	Do. 6 per Cent. 2nd Pref.	9 10	9 10	6 0 0	" "	..	..
61,653	15	9/0	Western and Brazilian	10⅜ 11⅛	10⅜ 11⅛	6 13 4	" "	11 7/16	11
30,364	7½	1/6	Do 5 per Cent. Cumulative Preferred	6½ 7	6½ 7	5 7 3	—	0⅛	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	4⅛ 4⅜	4⅛ 4⅜	.. ..	..	4 7/16	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	101 104	102 105	5 12 9	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	100 103	101 104	5 13 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	117 122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	101 105	101 105	5 14 3	March & September	104	..
			TELEPHONES.						
224,350	14/0	0/5½	Consolidated Telephone Const. & Maintenance	7/16 9/16	7/16 9/16	7 9 4	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid)	7/16 9/16	7/16 9/16	6 3 11	Yearly	..	..
438,984	5	3/6	National	4⅜ 4⅝	4⅜ 4⅝	6 3 1	June and December	4 13/16	4⅜
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½ 13½	12½ 13½	4 8 11	" "	13⅛	13
15,000	10	6%	Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd)	12½ 13	12½ 13	3 14 1	" "	..	..
350,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd)	105 107	105 107	4 4 1	..	106⅜	105⅛
58,000	5	1/0	United River Plate	2 3	2 3	.. ..	January and July ..	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85 95	85 95	5 5 8	—	..	..
			ELECTRICITY SUPPLY COMPANIES.						
1,000	£50	..	City of London Electric Lighting (£50 fully paid)	60 62	.. ..	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	4⅛ 5	4⅛ 5	..	..	..	..
5,322	£5	..	House to House Electric	4⅜ 5⅛	.. ..	..	..	..	..
30,000	£5	..	Liverpool Electric Supply (£3 paid)	2⅜ 2⅝	.. ..	..	..	..	..
111,000	5	..	London Electric Supply	1⅜ 2	1⅜ 1⅞	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	9½ 10½	9⅛ 10	4 7 7	..	9⅞	..
7,730	£5	3/6	St. James' and Pall Mall	6½ 7	6⅞ 7⅛	—	..	7	6⅛
..	..	7%	Do. 7% Preference	4⅛ 4⅜	4⅛ 4⅜	—	..	..	..
42,853	5	..	Westminster Electric Supply (£5 paid)	4⅜ 5⅛	5 5⅛	..	..	5 7/16	5 1/16
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978	3	..	Brush Electrical Engineering	2⅜ 2⅝	2⅜ 2⅝	.. ..	..	2 7/16	..
69,998	2	6%	Do. 6 per Cent. Preference	1⅞ 2	1⅞ 2	6 0 0	June and December	1⅛	1⅞
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	4 5	4 5	7 0 0	January and July ..	..	..
17,139	5	..	Edison and Swan United	.. ..	.. ..	..	—	..	..
45,000	10	6%	Electric Construction	3½ 4⅛	3½ 4⅛	..	—	4⅛	3⅞
70,000	2	10/0	Elmore's Patent Copper Depositing	3⅜ 4	3⅜ 3⅝	..	—	3⅛	3 7/16
20,000	5	..	Fowler-Waring Cables (£4 paid)	2 3	2 3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	19 20	19 20	5 0 0	February & August	19½	19½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103 105	103 105	4 4 11	March & September	..	..
11,334	£10	6/1	International Okonite Limited Ordinary	7⅛ 8⅛	7⅛ 8⅛	11 15 3	..	..	..
11,334	£10	5/0	Do. Preference	9⅛ 9⅞	9⅛ 9⅞	8 4 1	..	..	..
78,949	5	2/1½	Swan United (£3. 10s. paid)	4⅜ 5	4⅜ 5	6 19 10	May and November	4⅜	4⅜
37,350	12	12/0	Telegraph Construction and Maintenance	44 46	44 46	5 4 9	March and July.....	45⅜	44
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101 104	101 104	4 16 2	January and July ..	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£3 paid)	2⅛ 2⅜	.. ..	..	..	..	..
—	£5	..	Do. Preference (fully paid)	3⅜ 4⅛	.. ..	..	..	..	..
			RAILWAYS.						
50,000	£10	..	City and South London Railway	4 5	3 5	—	—	..	..

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THE ELECTRICIAN:

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NOTES.

The early date of the sixty-first meeting of the British Association, which opened at Cardiff on Wednesday, has accentuated the usual lack of information with regard to the Papers to be read. In Section A, Prof. W. Stroud will make "Some Revolutionary Suggestions on the Nomenclature of Electrical and Mechanical Units," and Mr. Preece will give us some further information on "The Magnetic Quality of Different Steels, and on Modes of Tempering," a complex subject, which was briefly dealt with in our columns a few weeks ago by Prof. Silvanus Thompson. Mr. F. T. Trouton will describe some experiments on "The Rate of Propagation of Magnetisation in Iron;" and Prof. D. E. Jones, of the Aberystwith College, is down for a Paper "On the Damping of Electric Waves along Wires," while Prof. Silvanus Thompson and Mr. Swinburne will each have something to say about standard cells. In Section G we may expect a little information with regard to the working of the London-Paris telephone line from Mr. Preece. Mr. A. R. Bennett will read two Papers, one on "The Telephoning of Great Cities" and another on "An Electric Parcel Exchange System;" and Prof. George Forbes will sum up our "Recent Progress in the Use of Electric Motors." A by no means striking programme. The British Association is, however, fruitful of surprises, and, although verging on the great climacteric, it frequently exhibits signs of youthful vigour, so that, in spite of outward and visible signs to the contrary, the Cardiff meeting may yet develop into a success from the electrician's point of view.

"The strange and startling rumour" which was said to have been in the air about this time last week, to the effect that Mr. Ferranti had severed his connection with the London Electric Supply Corporation and had left the country, probably originated from the fact that Mr. Ferranti had left *for* the country (a not unusual proceeding in August) and that his agreement with the Corporation terminated in due course at the beginning of the present month.

It was pretty evident from the tone of the Chairman's speech at the meeting of the shareholders of the London Electric Supply Corporation, last March, that as soon as everything was complete in connection with the present 90,000 light plant installed at Deptford, the first constructive period was to be considered at an end, and severe economies were to be effected. "We are now," the Chairman then said, "going to be mighty prudent, that is to say, before entering on the next stage of our operations, the stage which will complete and develop 200,000 more lights, we shall want some more money. I do not think we shall get it myself, or I do not think I shall have any hard in trying to get it, until we have established the first stage as a profitable commercial undertaking, because if you were to attempt to raise more money until that is tested, you could only raise it on disastrous terms." In consequence of this prudent determination here foreshadowed the engineering staff of the Corporation has been re-organised, with the result that it has been found possible (now that everything is working smoothly) to allow Mr. Ferranti to relinquish his responsible position of Chief Engineer.

We are glad to hear that more than 30,000 lights are now connected to the Deptford system, and that the Siemens and Fowler-Waring concentric cables, which have given entire satisfaction, have everywhere been substituted for the old overhead distributing network, now a thing of the past. Four transformer sub-stations are at present in regular operation—namely, the Grosvenor Gallery, Blackfriars, Trafalgar Square, and Deptford.

The difficulty in arriving at any definite information as to the cost of electric traction in this country, as compared with other systems, has been due to the fact that it has not been carried out on a sufficiently extensive scale. On another page, however, will be found an analysis of the accounts of the steam, horse, cable, and electric tramways worked by the Birmingham Central Tramways Company. At present the steam trams are carrying 58·5 per cent. of the passengers, while the cable takes 21·5 per cent., and the horse cars take 15·4 per cent., the electric trams only accounting for 4·7 per cent. of the whole number of customers. But, in spite of this very small proportion, the figures are extremely favourable to electricity. The proportion between the passengers carried by horses and by electric traction is as 100 is to 30·4, but the proportion between the balance carried to revenue in these two systems is as 100 is to 92, showing greatly to the advantage of electricity. This is partly explained by the first table, in which it appears that the electric trams carried nearly once and a-half as many passengers per car-mile as the horse trams and omnibuses, while the expenses per car-mile differ by only one per cent. The profit per car-mile for electric traction was more than four times that of horse traction; but interest on capital not being

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taken into account, and the depreciation being of a different kind, the actual figures cannot be accepted as representing the actual earnings.

PERHAPS the most satisfactory and encouraging part of the analysis is that which deals with the working expenses, for these are not affected by accidents of fares and districts. The skilled labour naturally burdens the electric system, but steam is only 21 per cent. lower, and horse traction offers a saving of only 6 per cent. in wages. The electric trams show a saving of 12½ per cent. over the steam trams in cost of fuel, and 55½ per cent. over the cost of forage and bedding. The repairs for electric cars were higher, but the expenses of permanent way were much lower than for steam. The general charges for steam and for electricity are identical, and the total expenses differ in favour of electricity by about 10 per cent., while horse traction is about 1 per cent. cheaper than its latest competitor. All the above comparisons are very encouraging, considering that only some half-a-dozen cars have been running for a twelvemonth, and it appears highly probable that if all three systems were carried out on an equal scale and under similar conditions the further saving of wages and fuel would amply provide for the wear and tear of battery plates, and leave a handsome balance in favour of electric traction. We hope that next year full information will be given as to capital charges, and that depreciation will be allocated to the different departments, so that a more strict comparison may be made.

IN our issue of the 7th inst. we alluded to two matters connected with photometry, the one raised by the gas companies, who ask the Board of Trade for more uniformity in the instruments which are "used against them," and the other by the County Council, who call for a more satisfactory standard of light. The first of these, and the one which is of comparatively small importance or interest to science or to engineering, has been met by a "Memorandum as to Photometers," issued by the Standards Department of the Board of Trade. It is announced that the Department will receive for examination and verification any photometer in use in connection with the sale of gas; but a certificate of verification will only be issued in respect of photometers of the Evans or Letheby forms. In our recent article we argued that the standard of light, as defined by the "parliamentary candle," was not provided, like a yard or a pound, as a standard to which buyers or sellers could refer, and still less can be said for these photometers, which are simply instruments for official testing of the quality of gas supplied. These may be compared to the chemical apparatus used by Dr. TIDY and Dr. FRANKLAND in their tests of the purity of our water supply. The Standards Department, on the other hand, have a very elaborate and accurate system of applying the standard of length to the determination of the cubic foot, and hence, by standard gas meters, to the verification o ordinary gas meters.

THE real cause of complaint about photometers seems to have been that ingenious improvements have been occasionally introduced by gas inspectors, and these may have been considered successful if they told against the gas companies. It is difficult to see what practical gain is effected. The Standards Department may be depended upon for verifying instruments only because they are really capable of enabling a skilled operator to make accurate comparisons; and they will not countenance any conventional or old-established method if not accurate. As nearly all photometric measurements, and certainly all of those under consideration, depend on the use of a balance or null method, the chief desideratum of a photometer is sensitiveness. The Memorandum, however, refers to the official verification of "the burner, meter, minute-clock, scale, governor, pressure-gauge, and other subsidiary measuring appliances." These have no interest whatever to the majority of our readers, and are connected with a rather clumsy attempt to provide a more convenient standard of light, and with the testing of gas rather than with photometers.

THE experiments of M. LEBLANC, which were described in a recent issue, makes the possibility of using paper and paraffin for the construction of condensers very hopeful. The success which he met in using thin ebonite does not appear to be so important, as the thickness is still too great, and the fact that the ebonite condensers stood 11,000 volts does not prove its superiority for practical purposes over such well-known, cheap, and easily-handled materials as paraffin and paper. Paraffin of great purity is commonly used for electrical purposes; its impurities are easily detected, and it can be well relied upon for not changing in any way with time. But there is hardly any material of which more varieties and qualities are to be found than paper, though, after experiments with a great number of kinds, Messrs. SWINBURNE and Co. only found one satisfactory sort. The "forming" process of M. LEBLANC, although supported, now that it has been hit on, by excellent theoretical reasons, was not likely to have been thought of deliberately, and was the result of a happy accident. Knowing the rubbish that is used in making paper, and the potent chemicals employed in inducing this rubbish to present a respectable appearance, we would hardly go so far as M. LEBLANC and say that one need not trouble oneself about the quality of the material so long as it undergoes the process of formation described. Continuity is the first essential, and homogeneity the second, while the process of formation is itself the best possible test of the finished article.

THE biography of Prof. VON HELMHOLTZ, accompanying the steel plate engraving published with the present issue, has been specially written for this journal by Prof. H. KRONECKER, of Berne, one of the great German *savant's* most successful pupils. We are indebted to Dr. GAMGEE, of Cambridge, for the admirable translation from the German. The concluding portion of the biographical sketch, dealing more especially with Prof. VON HELMHOLTZ's electrical work, will appear in our next issue.

Dublin.—The Town Council propose to replace their electric lighting licence of May 3, 1889, by a Provisional Order.

Belgrade.—The concession for the electric lighting of Belgrade has been secured by the firm of Tzikos, Pericles, and Caze.

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Budapest.—At a recent meeting of the Town Council it was decided to replace about 20 per cent. of the existing gas lamps in the streets by the electric light.

University College, Nottingham. — The Session 1891-92 of this College begins on Monday, October 5th. The engineering department is in charge of Prof. William Robinson. For further particulars see our advertisement columns.

Bristol.—The Electric Lighting Committee of the Town Council have decided to request Mr. Preece to furnish them with a written report, giving his reasons for selecting the particular machinery recommended to the Committee.

Personal.—We are informed that Mr. G. E Hartmans has resigned his position as Assistant Engineer to Messrs. Crompton and Co., and has joined Mr. J. G. W. Aldridge, consulting engineer, of 9, Victoria-street, Westminster, and Southampton.

Hampstead Vestry.—The Hampstead Vestry has resolved to apply for a Provisional Order authorising it to introduce electric lighting for public and private purposes. The Vestry has, however, not yet decided whether to carry out the lighting itself or to place it in the hands of a company.

Telephonic Communication between Stockholm and Christiania.—The last Swedish Parliament granted a sum of 60,000 crowns for the purpose of extending the telephone to the Norwegian frontier, on the condition that Norway should bring her telephone wires to the Swedish border. According to Norwegian papers the Storthing has acceded to this condition, so that direct telephonic communication between Stockholm and Christiania will shortly be established.

Pendant Switch.—Inquiry.—We have been requested to ask through our columns if there is such a thing to be had as a reliable pendant switch composed solely of earthenware, or other incombustible and non-hygroscopic material, with the necessary metal parts. Two forms are required by our correspondent, one for attachment to, or in combination with, a bayonet socket lamp holder, and the other to hang on the end of a flexible cord separate from the lamp.

Accident at the Agricultural Hall.—On the 28th ult. an arc lamp, which was hanging over the entrance of the Agricultural Hall, gave way and fell on a little girl. At the inquest, the electrician in charge of the electric lighting plant at the hall attributed the accident to a leak, which resulted in the current going to earth through the suspending wire. As a result the wire was burnt clean through, causing the lamp to fall. The wire was found to be hot after the accident occurred. The lamp was not alight at the time.

Telephony Abroad.—According to a French contemporary, the Belgian Government is contemplating telephonically connecting all the *chief lieux de canton* and large *communes* throughout the country to their respective provincial capitals. In Luxemburg, it seems, this has already been done, and even the smaller *communes* have been connected up. The atmosphere of small States apparently favours telephonic development, Sweden, Belgium, and the Grand Duchy of Luxemburg leading the way in the matter of cheap and extensive telephony.

Institution of Electrical Engineers.—With reference to our comments on the new rules of this Institution, in a recent issue, we understand that Associates can vote on any question that does not affect the Articles of Association, while the Institution of Mechanical Engineers do not allow either their "Graduates" or their "Associates" this privilege. As regards the additional "entrance fee" required on transfer from one class to another by the Institution of Electrical Engineers, it is to be noted that in the case of the Institution of Civil Engineers, in which no such additional payment is demanded, the same large entrance fee (£10. 10s.) is paid both by an Associate and a Member.

The Edison Convention.—The annual convention of the Edison Illuminating Companies was held in New York, on August 11th, 12th, and 13th. The following reports were down for presentation:—Report of Committee on the prevention of damage from crosses of high tension circuits; report of the Committee on lightning protection, and the results of experiments at the laboratory on new forms of lightning arresters; report of Committee on grounding the neutral wire in three-wire systems; report of Committee on fuel gas. Amongst the Papers to be read were:—"Important Details in Underground Conductors," by Mr. Stevenson; and "Peculiar Features of the Edison Feeder System," by Mr. Wilson S. Howell.

The Electric Lighting of Odessa Harbour.—The Odessa Harbour electric lighting plant constructed by the Thomson-Houston International Electric Company was taken over on July 8th by the Russian Government. There are in regular working 64 2,000 c.p. arc lamps, and eight 125 c.p. incandescent lamps. The arc lamp-posts vary in height from 43ft. to 30ft. There have been used about 10 miles of armoured cable, manufactured by Felten and Guilleaume, and also about 1,000 yards of submarine cable, 126 sq. mm. in cross-section, steel wire armoured. Where the submarine cable joins the land cable a Thomson-Rice cut-out is placed, allowing the cutting out of the submarine cable in case of fault. The generating plant consists of four 35-light series-wound arc dynamos, driven by belting from two central valve condensing Willans and Robinson high-speed engines. The two boilers are supplied by the Babcock and Wilcox Company.

Pisa.—At a meeting of the Town Council, on July 22nd, the terms on which a concession for the distribution of electricity would be granted were settled upon. From the pamphlet of regulations published by the authorities we gather that the period of the concession will not exceed 30 years, a provisional deposit of £400 will be required, and the firm finally obtaining the concession will have to deposit £2,000 as security. The leads may be laid either underground or overhead; in the latter case they must not be within 23ft. of the ground level. In case of a partial breakdown, lasting over 15 minutes, a fine ranging from 4s. to £40, according to the quantity of energy affected by the interruption, will be imposed. Should two total cessations of the supply, lasting over 15 minutes, occur within 30 days, the fine on the second occasion will be £80. Any disputes that may arise will have to be referred to a committee of arbitration consisting of three members.

Manchester.—According to the *Manchester Examiner and Times*, "The Electric Lighting Sub-committee appointed by the Gas Committee of the City Council have had under their consideration the reports of several consulting engineers as to the proposed installation of the electric light in Manchester. They have decided to recommend the appointment of an electrical engineer, who will advise as to the best system of lighting to be adopted, and will also superintend the operations of the contractor whose tender may be accepted for the work. This gentleman will receive a commission on the cost of the scheme, as is customary in the case of architects. The Sub-committee recommend that the 'lower pressure' shall be adopted, but further details of the scheme will be arrived at after the engineer has been appointed. It is proposed to confine the operations of the Committee entirely to a street installation; no apparatus in the interior of houses will be supplied, and those who desire to take advantage of the installation will have to execute their own connections. In this respect the Committee's scheme differs materially from the ordinary commercial operations of electric lighting companies." As no electric supply company of any standing now undertakes the business of interior fittings, we are unable to see where the material difference referred to comes in.

Damage by Lightning.—In the volume of Bavarian meteorological observations for 1890, Dr. C. Lang (the Director of the Service) contributes, says *Nature*, an article on the "Secular Variations of Damage by Lightning and Hail." He points out that in almost all recent investigations the conclusions come to are that during the last 50 years damage by lightning has much increased, but this is not borne out by his inquiry, but is probably owing to more attention having been paid to the subject recently. The numerous impurities introduced into the air of towns from fire-places, &c., would make it probable that they would be more liable to damage than country places, but exactly the opposite is the case, the ratio of damage to buildings in towns to that in the country being 1 : 2. This result is possibly to some extent due to the more numerous lightning-conductors, and to railway lines in the towns. He finds that

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the damage from hail shows a very probable connection with the period of sun-spot frequency, but the secular range of the former points more particularly to the influence of temperature, so that the curve of hail-frequency shows not only a minimum occurring with the 11-year sun-spot maximum, but also a period of about 35 years. The damage from lightning, on the other hand, does not show any connection with a secular range of temperature, but the minimum occurs with the maximum of sun-spot frequency. In other words, damage from hail seems to be more decidedly connected with terrestrial, and damage from lightning more with cosmical, influence.

Cornish Boilers.—In the course of the systematic tests of steam boilers undertaken by Mr. Bryan Donkin, jun., and Prof. A. B. W. Kennedy, an experiment was made upon three Cornish boilers in regular use by the East London Waterworks Company, which may be taken as exemplifying the performance of this class of steam generators when set and worked in good style, without an economiser. The experiment lasted from 8.50 a.m. to 6.50 p.m.; two of the boilers being fairly clean and the other rather dirty. The feed-water was taken from the hot well of the engine; and the furnace gases were sampled periodically at a point in the main flue where the products of combustion of all three furnaces united just before passing the main damper. The fuel used was the standard coal selected by Mr. Donkin for all the experiments. It is practically smokeless. In the present case the firing was done by the ordinary stokers. Each boiler was 30ft. long and 5ft. 9in. diameter, with a single flue 3ft. 6in. diameter, crossed by three Galloway tubes; the total heating surface of the boiler being 700 square feet. Rather thick fires were kept. The waste gases entered the chimney at a temperature of 485°F. The balance-sheet of the boilers showed that the heat accounted for in the water was 78·3 per cent., 14 per cent. going away in the furnace gases, and 4·4 per cent. being lost by radiation. The equivalent evaporation per pound of coal as burnt from and at 212°F. was after the rate of 11·4lb. of water. The absolute steam pressure maintained was 51·7lb.

The Telegraph in China.—The Chinese, who have for a long period evinced a remarkable aversion to the construction of railways, have, says *Iron*, shown themselves scarcely less amenable to the establishment of telegraphic communication. The first telegraph put into work in China was constructed in the year 1866, during the Formosan war, and connected the island of Pagoda with the arsenal of Foo-chow. The concession for this line was granted to a foreign company by the Viceroy of the province of Foohkin. But the Government itself disapproved of the concession and threw various obstacles in the way of the Company with a view to prevent the completion of the line. Happily, however, for the progress of telegraphy, these subversive attempts of the Chinese authorities were frustrated, thanks chiefly to the powerful intervention of the various foreign ministers at that time resident in Pekin. In addition to the official harassment, the Company had to contend with the prejudices of the native peasantry, who regarded with no small animosity, mingled with distrust, this invention *du diable*, as they termed it; and it was only with the utmost difficulty that the Chinese Hodge could be induced to respect the wires. Since those eventful times the telegraph in China has been largely extended. There is a line from Pekin to Tientsin; another placing the capital in communication with the principal Manchurian towns, and continued to the Russian frontier, on the Amour and the Oussouri. The seven treaty ports on the Yang-tse-Kiang and the chief cities of the empire are connected between themselves and with the capital. A line from Canton has been extended in a westerly direction as far as Yunnan-Foo, capital of the province of Yunnan, near the borders of French Tonquin. Other wires have been laid between Foo-Chow and Canton, and between Port-Arthur and the capital of the Corea. The line which follows the valley of the Yang-tse-Kiang has stretched far into the interior of the country. As the result of a recent arrangement between the Chinese and Russian Governments, the native and Siberian lines unite in the valley of the Amour, thus securing direct telegraphic communication between Pekin and Europe.

Electric Apparatus for the London Fire Brigade.—The following extracts from the specification of work to be done and materials to be supplied in placing and maintaining in perfect order for a period of three years the electric bells, apparatus, working and fittings at all the Fire Brigade stations belonging to the London County Council may be of interest:—(*a*) The contractor is required to provide a telephone line between the chief station of the brigade and his office, by means of which requisitions for any work necessary will be transmitted to him, and all such requisitions reaching him between 8 a.m. and 5 p.m. must be attended to within two hours, and the work as far as possible carried out on the same day. (*b*) The cells are to be cleaned at least once in every six months, and from time to time as required, and recharged when necessary, and any new parts provided when required. (*c*) Any cell which on open circuit does not give at least 1 volt when tested immediately after ringing the bells connected to the battery of which it forms part for a continuous period of 30 seconds, must be at once renewed. The batteries must be maintained in such condition as to give not less than 8 volts at the terminals of the bells when all are ringing, unless a different figure shall be fixed by the chief engineer in any special case. (*d*) Bells are to be adjusted as requisite, and all bells ringing off the same battery are to have approximately equal resistance, and if the chief engineer shall so determine, existing bells which do not comply with this condition are to be replaced, and any bells which the contractor is unable or fails for 24 hours to put in perfect ringing order are to be replaced with new bells of approved kind. These will usually be required to have a resistance of from 45 to 50 ohms. (*e*) The automatic switches are to be adjusted and maintained to ring the bells to which they are connected for a continuous period of either 15 seconds or 20 seconds as directed. (*f*) All new insulators for outside wires are to be fluid insulators of approved pattern, the wires to be shackled off at each post or support. (*g*) All new posts are to be galvanised iron, with galvanised iron shoes and crossbars.

Electrical Subways in Brooklyn.—The final report of the Brooklyn Board of Commissioners of Electrical Subways, issued two years ago, still remains, says R.W.R. in the *Engineering and Mining Journal* of New York, the best summary statement of the municipal problem with which it deals. In one noteworthy particular the opinion and prophecy of the Board have received a striking confirmation. I refer to the matter of the corrosion of lead in conduits of creosoted wood. This evil was at one time very threatening, and so important that, although it constituted the only serious objection to the use of such wooden conduits, it might have counterbalanced, if remedy had proved impracticable, all the great advantages of that material. One concern, at least, engaged in the manufacture of lead-covered cables declined to guarantee them if laid in creosoted conduits. The remedies suggested were two: the alloying of the lead with about four per cent. of tin, which, however, rendered the cables both more expensive and more difficult to manufacture; and the use of a fibrous covering, which was somewhat objectionable on other grounds. The Brooklyn Board, however, caused careful laboratory tests and analyses to be made, and announced in its final report that, in its opinion, the corrosive agent is "phenol, which, being highly volatile, either escapes from the wood in the process of seasoning, or could be expelled more rapidly, if required, by artificial means." The frequent occurrence of the phenomenon of corrosion in different cities was, no doubt, due to the haste with which underground conduits were everywhere constructed during that period of spasmodic reform under "scientific" legislation. Experience has proved that the Brooklyn Board was right. The two-year-old Brooklyn conduits do not now corrode lead—even pure lead—appreciably; and in some other cities where the authorities and electrical companies were almost ready, in a panic, to abandon the system, the simple lapse of time has cured the difficulty. The underground system in Brooklyn seems to be running so peacefully and successfully that it is never heard of. If the Legislature had not summarily abandoned the whole experiment, that city might now be a model in the extent, as it is confessed to be in the simplicity and perfection, of its subways.

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THE HISTORICAL DEVELOPMENT OF THE INDUCTION COIL AND TRANSFORMER.

BY DR. J. A. FLEMING, M.A.

(Concluded from page 361.)

§ 20. Sir. W. Grove's Employment of Alternating Currents with an Induction Coil.—Shortly after the publication of the description of Wilde's magneto-electric generator, Sir W. Grove had the idea of exciting an induction coil with an alternating current. He accordingly applied an ordinary medical magneto-electric machine to the primary of a Ruhmkorff coil, first screwing up the contact breaker of the coil, so as to close the primary circuit, and cut out the condenser. He found to his surprise that he could get no secondary discharge at all. When, however, he opened the contact breaker, so as to place the condenser in series with the primary coil and the magneto-electric machine armature, he got sparks of about one-third of an inch in length between the ends of the secondary coil. Not being able himself to see fully the reason for this he appears to have shown or described the experiment to Clerk-Maxwell, who sent him the explanation of it. (See *Phil. Mag.*, Vol. XXXV., 5th series, 1868, p. 360.)

Maxwell pointed out that the reason why he obtained no sparks from the secondary circuit, when the condenser was short-circuited, and the magneto-electric machine was applied directly to the primary of the coil, was because the self-induction of the primary coil prevented the alternating electromotive force of the generator from developing any but a very small current in the primary coil. When, however, the condenser was thrown into series with the primary coil by opening wide the contact points, the capacity of the condenser annulled a great part of this self-induction of the primary circuit, and hence permitted the alternating E.M.F. of the generator to send a much larger current through the primary coil, and this was able to generate a very considerable secondary current and secondary electromotive force. The condenser neutralised in part the impedance of the primary circuit. In this same Paper, Clerk-Maxwell sketched out the mathematical theory of the shunted condenser in series with an inductive circuit as follows:—Let V_0 be the maximum value of the periodic electromotive force of the generator, and let R and L be the resistance and inductance of the primary circuit of the coil, and C the capacity of the condenser shunted by a non-inductive resistance, r, arranged as in Fig. 26. Then the following relations hold good:—Let v_1 be the potential difference of the condenser-plates at any instant, and let i_1 be the current through the primary coil, and i_2 the current through the condenser shunt. Also let I_1 be the maximum value of the current in the primary coil. If v_0 is the E.M.F. of the generator, then we may write

$$v_0 = V_0 \cos p t$$

as the expression for this instantaneous value of the E.M.F. in terms of its maximum value, where p stands for 2π times the frequency of the alternating current or electromotive force; also we can write

$$i_1 = I_1 \cos (p t + \alpha),$$

and

$$v_1 = r i_2.$$

Hence we have

$$C \frac{d v_1}{d t} = i_1 - i_2,$$

and

$$V_0 \cos p t + R i_1 + L \frac{d i_1}{d t} + v_1 = 0,$$

as equations true at any instant, and it is easy to deduce that the maximum value I_1 of the current in the primary is given by

$$I_1^2 = \frac{V_0^2 (1 + C^2 r^2 p^2)}{r^2 \{(1 - L C p^2)^2 + C^2 R^2 p^2\} + 2 R r + R^2 + L^2 p^2}.$$

If $r = 0$, that is, if the condenser is short-circuited, this reduces to

$$I_1^2 = \frac{V_0^2}{R^2 + L^2 p^2} \quad \ldots\ldots \quad (1)$$

If $r = \infty$, that is, if the shunt is removed, it reduces to

$$I_1^2 = \frac{V_0^2}{R^2 + \left(L p - \frac{1}{C p}\right)^2} \quad \ldots\ldots \quad (2)$$

In the case when $2 C L p^2$ is greater than unity, the value of I_1 given by (2) is greater than the value given by (1). Hence the primary current is *increased* by throwing into circuit a suitable condenser. If $C L p^2 = 1$ the expression for the current is reduced to

$$I_1 = \frac{V}{R},$$

or the current has the greatest value it can have, and the inductance of the primary circuit is entirely annulled by the condenser.

Maxwell thus pointed out the condition for obtaining the maximum primary current and the reasons why the interposition of a condenser of suitable capacity increases the primary current, and hence increases the secondary electromotive force to the point of creating very considerable sparks between the secondary terminals.

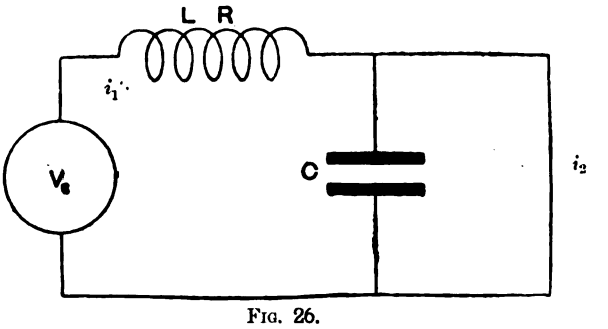

FIG. 26.

§ 21. Mr. Apps' Large Induction Coils, the Polytechnic Coil, and Mr. Spottiswoode's Great Coil.—In the years since 1867, Mr. A. Apps has devoted great attention to the production of large induction coils, and has been the designer and constructor of some of the most powerful coils in existence. Mr. Apps began by making coils of single flat spirals of wire insulated by discs of insulating material, but finding this construction too expensive, he adopted a modified form of the sectional winding. In 1869 he built the large Polytechnic coil, sometime exhibited and used at the old Polytechnic Institution of London. The secondary wire of this coil was 150 miles in length. The diameter of the wire was ·014 of an inch, and it was silk-covered. This secondary wire was wound in grooves about ⅛ of an inch in width and 200 in number. The iron core was a bundle of soft iron wire, 4in. in diameter, weighing 123lbs., and about 5ft. in length. The primary bobbin weighed 145lbs., and consisted of 6,000 turns of covered copper wire ·095 of an inch in diameter and 3,770 yards in length. The secondary bobbin when complete had an external diameter of 2ft. and a length of 4ft. 10in. The primary coil was insulated from the secondary coil by an ebonite tube. Excited by the current from 40 large Bunsen cells, this coil would give secondary sparks 29in. in length, and could in a few seconds charge 66 Leyden jars, each having 11 square feet of internal coated surface. The secondary discharge could pierce blocks of glass 5in. in thickness. The secondary sparks were of considerable thickness and apparent volume, and accompanied by a kind of flame. The next coil of any importance was an 18in. spark coil made for the late Mr. Spottiswoode, which was made on the same general lines as the Polytechnic coil. After introducing many improvements, Mr. Apps began, in 1876, to construct his most important induction coil, viz., the colossal induction coil built for the late Mr. Spottiswoode, which is described as follows in the *Philosophical Magazine* for January, 1877, p. 30, and which was used by Mr. Spottiswoode in many of his researches. It is thus described in the above-mentioned periodical by Mr. Spottiswoode himself:—

"The general appearance of the instrument is represented in Fig. 27, by which it is seen that the coil is supported by two

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massive pillars of wood, sheathed with gutta-percha, and filled in towards their upper extremities with paraffin wax. Besides these two main supports, a third, capable of being raised or lowered by means of a screw, is placed in the centre, in order to prevent any bending of the great superincumbent mass. The whole stands on a mahogany frame resting on castors.

"The coil is furnished with two primaries, either of which may be used at pleasure. Either may be replaced by the other by two men in the course of a few minutes. The one to be used for long sparks, and indeed for most experiments, has a core consisting of a bundle of iron wires, each ·032in. thick, and forming together a solid cylinder 44in. in length and 3·5625in. in diameter. Its weight is 67lbs. The copper wire used in this primary is 660 yards in length, ·096in. in diameter, has a conductivity of 93 per cent., and offers a total resistance of 2·3 ohms. It contains 1,344 turns wound singly in 6 layers, has a total length of 42in., with an internal diameter of 3·75in. and an external of 4·75in. The total weight of this wire is 55lbs.

"The other primary, which is intended to be used with batteries of greater surface, *e.g.*, for the production of short thick sparks, or for spectroscopic purposes, has a core of iron wires ·032in. thick, forming a solid cylinder 44in. long and 3·8125 in diameter. The weight of this core is 92lbs. The copper wire is similar to that in the primary first described, but it consists of 504 yards wound in double strand forming three pairs of layers, whose resistances are ·181, ·211, ·231 ohm respectively. Its length is 42in., its external diameter 5·5in., and its internal 4in. Its weight is 84lb. By a somewhat novel arrangement, these three layers may be used either in series as a wire of ·192in. thickness, or coupled together in threes as one of ·576in. thickness. It should, however, be

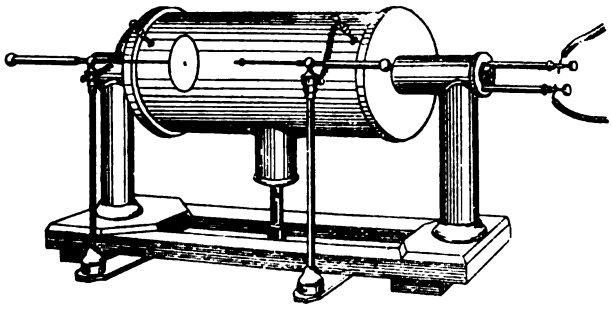

Fig. 27.—Mr. Spottiswoode's Great Induction Coil, made by Mr. Apps (1876).

added that, owing to the enormous strength of current which this is capable of carrying, and to the highly insulated secondary coil being possibly overcharged so as to fuse the wire, this larger primary is best adapted for use with secondary condensers of large surface, for spectrum-analysis, and for experiments with vacuum tubes in which it is desirable to produce a great volume of light of high intensity, as well as of long duration at a single discharge. The alternate discharges and flaming sparks can also be best produced by this primary. It has been used for high-tension sparks to 34in. in air, the battery being 10 cells of Grove's with platinum plates 6¼in. × 3in. Great facilities for the use of different sets of batteries are afforded by the division of this primary into three separate circuits, to be used together or separately; and by a suitable arrangement of automatic contact breakers, the primary currents may be made to follow in a certain order as to time, duration, and strength, with effects which, when observed in the revolving mirror, will doubtless lead to important results in the study of striæ in vacuum tubes.

"The secondary consists of no less than 280 miles of wire, forming a cylinder 37·5in. in length, 20in. in external and 9·5in. in internal diameter. Its conductivity is 94 per cent., and its total resistance is equal to 110,200 ohms. The whole is wound in four sections, the diameter of the wire used for the two central sections being ·0095in., and those of the two external being ·0115in. and ·0110in. respectively. The object of the increased thickness towards the extremities of the coil was to provide for the accumulated charge which that portion of the wire has to carry.

"Each of these sections was wound in flat discs; and the average number of layers in each disc is about 200, varying, however, with the different sizes of wire, &c. The total number of turns in the secondary is 341,850.

"The great length of the wire necessary can be easily understood from the fact that near the exterior diameter of the coil a single turn exceeds 5ft. in length. The spark, it is believed, is due to the number of turns of wire, rather than to its length, suitable insulation being preserved throughout the entire length. In order to ensure success, the layers were carefully tested separately and then in sets, and the results noted for comparison. In this way it was hoped that step by step safe progress would be made. As an extreme test, as many as 70 cells of Grove's have been used, with no damage whatever to the insulation.

"The condenser required for this coil proved to be much smaller than might at first have been expected. After a variety of experiments, it appeared that the most suitable size is that usually employed, by the same maker, with a 10-inch-spark coil—viz., 126 sheets of tinfoil 18in. × 8·25in. in surface, separated by two thicknesses of varnished paper, the two thicknesses measuring ·011in. The whole contains 252 sheets of paper 19in. × 9in. in surface.

"Using the smaller primary, this coil gave with five quart cells of Grove, a spark of 28in., with 10 similar cells one of 35in., and with 30 such cells one of 37·5in. and subsequently one of 42in. As these sparks were obtained without difficulty, it appears not improbable that, if the insulation of the ends of the secondary were carried further than at present, a still longer spark might be obtained. But special adaptations would be required for such an experiment, the spark of 42in. already so much exceeding the length of the secondary coil.

"When the discharging points are placed about an inch apart, a flowing discharge is obtained both at making and at breaking the primary circuit. The sound which accompanies this discharge implies that it is intermittent, the time and current spaces of which have not as yet been determined.

"With a 28in. spark, produced by five quart cells, a block of flint glass 3in. in thickness was in some instances pierced, in others both pierced and fractured, the fractured pieces being invariably flint glass. If we may estimate from this result, the 42in. spark would be capable of piercing a block 6in. in thickness.

"When used for vacuum tubes this coil gives illumination of extreme brilliancy and very long duration: with 20 to 30 cells and a slow-working mercury break, giving, say, 80 sparks per minute, the striæ last long enough for their forward and backward motion to be perceived directly by the unassisted eye, The appearance of the striæ when observed in a revolving mirror (as described in the *Proceedings of the Royal Society*, Vol. XXV, p. 73) was unprecedentedly vivid, and this even when only two or three cells were employed.

"Further experiments have shown that with such large coils only the newly discovered effects of very high temperature-combustion or volatilisation can be produced. On exciting the primary of the coil with a suitable dynamo-electric machine, or battery, and using a large Leyden jar in the secondary circuit (according to Sir William Grove's experiment), the electrical discharge passing between electrodes placed before the slit of the spectroscope lines and bands may be observed to advance and recede according to the variations made in the magnitude of the exciting discharges. As the atmospheric pressure may be assumed to remain constant, these effects are probably due to differences of temperature arising from the action of a greater or smaller extent of electrical effects on the electrodes in a given time."

Following on this great coil Mr. Apps has made many others, such as the 20in. spark coil made for the Framjee Kawasjee Institute of Bombay, and by certain devices of insulation has increased the length of the secondary spark beyond the length of the bobbin, thus making a bobbin of 8½in. in length give an 11in. spark. As an illustration of this fact Mr. Apps has, by permission, furnished the author with the details of six coils made for Lord Armstrong, the measurements of which are as follows:—

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The secondary circuit consists of 8 miles 25 yards of silk-covered copper wire, ·0064in. in diameter. It makes 41,425 turns, and weighs in all 7lbs. 1oz. 7drs. The secondary circuit resistance is 12,500 ohms. The interior diameter of the secondary bobbin is $3\frac{5}{16}$in., the exterior $5\frac{7}{16}$in., and the length $8\frac{5}{8}$in. The secondary spark is from $10\frac{1}{4}$in. to 11in. in length. The primary coils consist of square copper wire, No. 14 B.W.G., the length of wire on each bobbin being 51 yards, laid on in four layers of 366 turns. The primary coil resistance is ·32 ohm. The length of the primary coil is 9·1in.; the outside diameter of the bobbin is 2in., and the

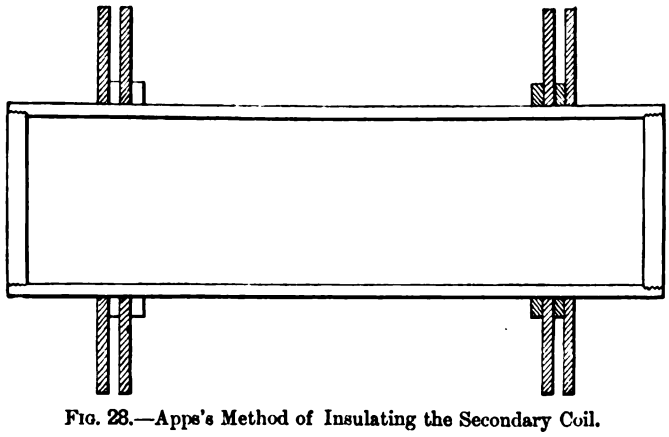

Fig. 28.—Apps's Method of Insulating the Secondary Coil.

inside diameter 1·6in. The most effective primary current is a current of 12 amperes and 10 volts. Each coil is fitted with a condenser divided into six parts. The details of the processes by which these remarkable achievements in insulation are produced are of the nature of trade secrets, but generally it may be said that the greatest precautions have to be taken to secure the result. Mr. Apps has obtained a high reputation by the excellent performance of many of his coils.

Some of Mr. Apps's improvements in induction coils are described in his British Specification, No. 177, of January 24, 1867. In this he gives the details of improvements in

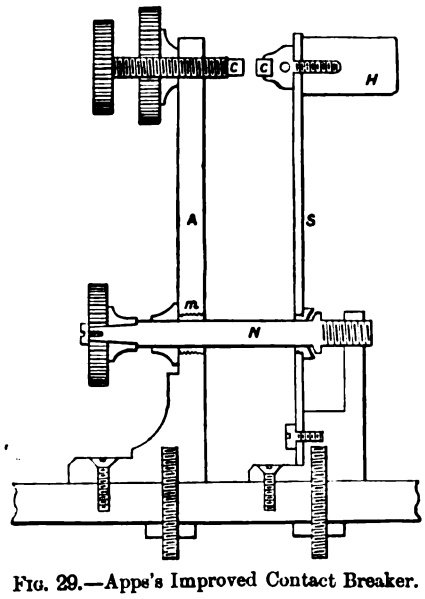

Fig. 29.—Apps's Improved Contact Breaker.

the mode of insulating the secondary coil, and in the construction of the contact breaker. His method of obtaining high insulation between the primary and secondary coil is as follows:—The primary coil is wholly enclosed in an ebonite tube (*see* Fig. 28), which projects beyond the secondary coil for some distance. On this ebonite tube are slipped, alternately, a series of ebonite discs and ebonite rings, which act as distance pieces separating the discs, and thus form a series of narrow grooves or compartments in which the secondary coil is wound. The secondary coil is then laid in these grooves, each section being carefully insulated and tested, and the several sections joined up so that no two portions of the wire which come very near to each other are at very different potentials. Besides greatly improving this groove mode of winding, Mr. Apps devoted attention to the contact breaker. He gave it the form shown in Fig. 29. In this figure S is the spring which carries the hammer head H. The pillar A is perforated and bushed at *m* with an insulating collar, and a tightening screw, N, serves to press back the hammer spring, if desired, so that the platinum contacts, *c*, *c*, are pressed more tightly in contact, and the time of vibration of the spring, S, is increased. This enables the rate of break to be altered even during the working of the coil. Mr. Apps has devised a form of multiple contact break which renders it possible to divide the break spark between several points.

It cannot be said that any subsequent improvements have been made which have altered for the better the mode of construction adopted by Mr. Apps for the construction of the induction coil since his chief large coils have been made. Other makers have introduced little changes of arrangement, but the essential features in all good coils remain the same, and even the general form of the coil is not much varied. Some changes of manufacture have been introduced, such as that in Pyke and Barnett's induction coil (*see* Fig. 30). In this coil the hammer break is erected on the top of a vertically placed coil. The hammer is mounted on a short thick spring and is

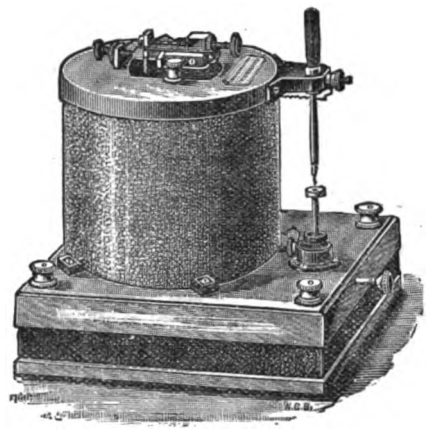

Fig. 30.—Pyke and Barnett's Induction Coil.

rapidly vibrated by an auxiliary electro-magnet, the exciting coils of which are in a shunt circuit to the main primary coil. The main coil contacts are so mounted that their normal position is in contact, one of them being carried on a spring. The vibrating hammer in its excursion strikes against one of these contacts and separates them slightly and instantaneously, thus interrupting the circuit of the primary coil.

The whole of the parts are arranged for ready and rapid adjustment. The discharging terminals of the secondary circuit are arranged at the side of the coil in a convenient manner.

A California Mining Plant.—The Dalmatia Mine is situated in the California Mountains, 1,500ft. above the sea, and nearly 60 miles from Sacramento. Fuel being dear, the question of obtaining power for operating the mine was a serious one. After deliberation it was decided to install an electric plant. The nearest water is Rock Creek, a stream running into the American River. The creek was tapped about two miles above the point where it empties into the river, and the water was then led through ditches dug and blasted through the rock to a point about 100ft. above the river. The power station is placed close to the river, and the water is led into it through a 28in. iron pipe. At the power-house is installed a large Pelton waterwheel, driving a jack shaft, to which is belted a Brush compound generator, giving 1,800 volts and 40 amperes. The current is taken by an overhead copper wire over the mountains to the mine, one and a-half miles distant, where the motor equipment is situated, driving the stamps and other mining machinery.

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The Electrician.

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With this week's number of "THE ELECTRICIAN" we issue (gratis to Subscribers) a fine Steel-Plate Portrait of Professor von Helmholtz. Complaints of non-receipt should be promptly made to the Publisher.

SECONDARY BATTERIES.

Since the FAURE battery was introduced and described in a letter to *The Times* of May 16, 1881, as the marvellous "box of electricity," there has been ample time to gain experience of the commercial value of lead secondary batteries, and to form a judgment as to their prospects, and it is not without interest to recall the expectations aroused by it and see how far they have been realised. Sir WM. THOMSON, in his letter to *The Times*, dated Glasgow, June 6, 1881, hailed the advent of the FAURE battery as a solution of that most important problem, the conversion of electrical energy into a preservable and storable form, so that it could be used at any time when wanted. Referring to the long felt want of a battery which could have the chemical energy restored to its elements by being worked backwards by a steam-engine and dynamo, Sir WILLIAM says:—"But with all ordinary forms of voltaic battery the realisation of the idea seemed hopelessly distant. By PLANTÉ'S admirable discovery of the lead and lead peroxide voltaic battery, alluded to by your correspondent, an important advance towards the desired object was made 20 years ago; and now by M. FAURE'S improvement practical fruition is attained." This enthusiasm appears to have been generally shared, and with the invention of pasted plates the problem of the storage of electrical energy was taken as solved. Secondary batteries were to do for electric lighting "what a water cistern in the house does for an inconstant water supply," our tram cars and launches were to be driven by them, and the Herculean task of purifying the atmosphere on the Underground Railway was to be performed by using them, instead of steam engines, as a source of the motive power for the trains.

Ten years' experience cannot, however, be said to have realised the hopes then entertained. Although they are now largely used for electric lighting, no thoroughly satisfactory battery for traction purposes has yet been introduced, and we still have to submit to disinfection with sulphur, and to being blackened by soot, whenever we are compelled to travel on the Inner Circle. It is, therefore, important to discover whether the causes of the principal defects which have retarded the introduction of lead secondary batteries, *i.e.*, "buckling" and "sulphating," are such as can be remedied by improved

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methods of manufacture, or whether they are traceable to the chemical reactions always occurring in normal working. Innumerable batteries have been brought out since the date of FAURE's great discovery, and much ingenuity has been displayed in effecting improvements in the mechanical structure of the plates, both of the PLANTÉ and FAURE type. Taking advantage of the experience gained in the manufacture of sulphuric acid that lead is much less attacked by the acid when containing antimony than when pure, the grids in the FAURE type of cell were alloyed with antimony, with the result of increased strength and durability. Many devices have also been resorted to to obtain and maintain good contact between the paste and the grid, with the result that considerable improvement has been effected in storage capacity. But, all these mechanical improvements notwithstanding, the various batteries have exhibited the characteristics observed by PLANTÉ in his cell. In all there is a rise of electromotive force on breaking the discharging circuit, with a corresponding fall on breaking the charging circuit; and a sudden lowering of the electromotive force at the end of discharge, not due to the exhaustion of the active material, since after a rest the battery will yield a further discharge. As sulphating and buckling also occur to a greater or less extent in all the batteries yet introduced, they would appear to be due, like the peculiarities in electromotive force, which PLANTÉ ascribed to the action of peroxides in the electrolyte, to chemical reactions common to the whole class of lead peroxide—sulphuric acid—lead cells, and not to any particular method of manufacturing the plates.

Turning to the work which has been done on the subject by physicists and chemists we find that in a Cantor lecture delivered in 1883, Prof. OLIVER LODGE pointed out that the sudden running down of the cell was not due to the exhaustion of the peroxide plate, as the cell would continue discharging if the lead plate was removed and a fresh one inserted. He also showed that the recovery of the electromotive force exhibited by the cell on rest is only to a very slight extent due to the peroxide plate. MIESLER has shown that, while the potential difference between the acid and the peroxide plate only exhibits a very slight falling off, even when the discharge is continued until the electromotive force of the cell has fallen to half its original value, that between the lead plate and the acid decreases very rapidly, and reverses at about 1·5 volts. This confirms Prof. OLIVER LODGE's observations, shows that the alteration in the electromotive force must be due to some change in the nature of the chemical compounds formed on the lead plate, or in the acid next it, and also shows that the changes occurring at the peroxide plate must be practically identical throughout the discharge. In reply to Dr. FRANKLAND's oxysulphate theory, Messrs. GLADSTONE and HIBBERT have shown that the formation of oxysulphates by the action of dilute acid on litharge and red lead respectively is very doubtful. However, since in the cell on starting the discharge we are dealing with the action of sulphuric acid on peroxide of lead and lead respectively, even if oxysulphates corresponding to the monoxide and sesquioxide of lead exist, it remains to be proved that these oxides are formed in the discharge of the cell before Dr. FRANKLAND's hypothesis of the action of the cell can be accepted. Mr. G. H. ROBERTSON has shown that the normal action of the cell gives rise to the formation of persulphuric acid in the first instance, and that this body forms hydrogen peroxide by secondary action, and, further, that the addition of hydrogen dioxide to the acid causes a lowering or reversal of the electromotive force in the case of a lead peroxide—lead couple. We are, therefore, in a position to account for the sudden lowering of the electro-motive force and also for the sulphating of the surface of the plates which takes place during rest, and which local action seems scarcely to explain. Although the knowledge of all the chemical actions involved in charge and discharge which we now possess does not enable us to suggest the addition of any substance to dilute sulphuric acid which shall permanently prevent the formation in it of deleterious bodies, and at the same time be harmless to the plates, we can now bring back to health damaged plates, and tell when the acid is getting into a bad state, and thus prevent injury to them.

For electric lighting, lead secondary batteries seem likely to fulfil the hopes entertained of them, particularly in connection with Central Station work. On the other hand we do not seem appreciably nearer a light and durable secondary battery for traction work. The great weight of a lead cell immediately places it at a disadvantage. Moreover, when we remember that in a fully charged cell, the peroxide paste is in such a finely divided and disintegrated state that it cannot be touched without removing some of the active material we can imagine what must be the speedy result of the constant wash produced by the movement of a car. We may prevent the formation of deleterious bodies in the acid as effectually as we like, but weight can only be diminished, and the injurious effects of wash can only be overcome by a radical alteration in the type of cell employed. It would seem, therefore, that we must look to some new departure, such as the alkaline copper cell, or Dr. PAUL SCHOOP's gelatinous electrolyte and not to a modification of the lead peroxide, sulphuric acid, lead cell for a completely satisfactory self-contained apparatus for the propulsion of tram cars.

HERMANN VON HELMHOLTZ.

Some thirty years ago the scientific visitor to Heidelberg could not fail to be interested in a large house, the "Riese," or giant, as it was termed, situated at the west end of the principal street of that town. The first floor of this house afforded shelter to the physiological, the second to the Physical Institute. In the upper story of this house Kirchoff and Bünsen compared the spectra of the metals with those of the sun; a few steps lower, Helmholtz built up the vowel sounds by combining the tones of vibrating tuning forks; Wilhelm Wundt, his then assistant, here taught us how graphically to record the contractions of the muscles, whilst the students, more inclined to play than to work, busied themselves with their prescribed practical exercises, which consisted in grinding teeth into slips of microscopic thinness.

When Helmholtz, our great master, walked through our work-rooms, and the quiet but penetrating glance of his large, mobile eyes fixed itself on our insignificant work, we listened with strained attention to his instruction. In general, his directions were expressed in few words, yet these were sufficient to cause us to work for days, both with our heads and our hands. For, besides attending to the ideal conception of a research, he did not in the least neglect the practical working details. I remember how, during many weeks, he made me build up a myograph out of the boards of a cigar-box, knitting needles, cork sealing-wax, and glass plates, and his great head nodded friendly approval at this 'prentice work of mine.

To-day that the whole world of learning celebrates his jubilee, and the German people, with just pride, congratulate their Helmholtz, and it appears becoming that we should cast a light over the path by which the great man reached his high position.

Hermann Ludwig Ferdinard von Helmholtz was born on August 31, 1821, at Potsdam, where his father occupied the position of a teacher in the "gymnasium." In his seventeenth year he entered the University of Berlin as a student. Helmholtz would have liked to have devoted himself to the study of

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physics. Circumstances, however, compelled him to enter on the study of medicine, a course which was rendered easy for him by the liberal arrangements of the Frederick William Institute, an institution for the training of military surgeons. The education which he there received he has never regretted. In his speech "On Thought in Medicine," delivered at the commemoration of the foundation of the Institute for the Education of Military Surgeons in Berlin, on August 2, 1877, he esteemed "that to have been a real happiness which he at one time had felt to be burdensome." He expresses himself thus:—"Apart from the fact that I entered on the study of medicine at a period when anyone who was even moderately skilled in physical modes of examination found a fruitful virgin soil to cultivate, I consider the study of medicine to have been the school which taught me, as no other could have done, the eternal laws which are the bases of all scientific work." The high conception which he entertained of the aims and objects of medicine may be gathered from the following quotation:—"The proud saying of Hippocrates served almost as the watchword of the old deductive medicine 'ἰητρός φιλόσοφος ἰσόθεος' (godlike is the physician who is a philosopher)." If we conceive the philosophical physician of Hippocrates to be a man possessed of consummate insight into the causal relations of the processes of nature, we shall be able to say of such a man that he will indeed be able to render aid even as a god might do. So understood, the sentence of Hippocrates expresses, in three words, the ideal which our science has to strive after. Who shall say whether it will ever be attained?"

Medical education, at the time when Helmholtz, studied depended still essentially on the study of books; microscopes were still dear and rare. "I myself," relates Helmholtz, "succeeded in becoming possessed of one by falling ill of typhus fever during the autumn holidays of 1841, when, being as a pupil gratuitously treated in the Charité, I found myself, on my recovery, in possession of that part of my small income which had been accumulating during my illness. The instrument was not beautiful, yet by its aid I was able to recognise the nervous processes of the ganglion cells of invertebrates, which I described in my dissertation, as well as the vibrios referred to in my work on putrefaction and fermentation."

His inaugural thesis for the doctor's degree (November 11, 1842), the researches for which he undertook at the suggestion of the great Johannes Müller, afforded evidence of his intense power of observation, which always led him to discover the most important facts. This rare quality manifested itself likewise in the second work, already referred to, "On the Nature of Putrefaction and Fermentation" (1843). With all the strictness which the modern investigation of septic processes has been able to attain, did he demonstrate that putrefaction is not brought about, as Liebig had supposed, by the oxygen of the atmosphere, but that superheated air is entirely incapable of bringing about putrefaction or fermentation. In putrefying liquids he observed, with a magnifying power of 400 diameters, small spherules and large rod-shaped organisms, which moved slowly, and rotated around their long axes. Small pieces of boiled meat, enclosed in flasks, were likewise found by Helmholtz not to putrefy when he passed an electric current through the liquid, and, by the decomposition of water, set oxygen free. Schwann, his distinguished comrade in the laboratory of Johannes Müller, had already shown that vegetable cells bring about fermentations in solutions of sugar, which the introduction of superheated air was unable to induce. Helmholtz might, therefore, have considered his analogous observation as sufficient and complete in itself. But his scientific critical acumen, waging war against all sources of error, caused him to extend his observations. The extraordinary difficulties which these presented, at a time when many of our more valuable modern methods of investigation were not available, led to results which somewhat misled him. Surprised and doubtless disappointed by the conclusions to which his final experiments appeared to point, we find the youthful investigator (for he was still only 22 years of age) bowing modestly before the unwelcome truths of Nature, and formulating his conclusions as follows: "From these researches it appears that putrefaction may originate independently of vital processes." Thirty-nine years later he appended to the re-publication of this work ("Ges. Abhandl.," Vol. II., p. 737) the following remarks:—"Recent researches make it probable that organisms of very minute size (which the extraordinary magnifying power, modes of illumination, and methods of staining, of the present day, have for the first time allowed us to recognise) are able to pass through, or to grow through membranes.' At that time Helmholtz occupied the post of military surgeon in Potsdam. But he remained faithful to his scientific mission. He contributed to the "Advances in Physics" published by the Physical Society of Berlin. The invitation to write the article on "Heat" in the Encyclopœdic Dictionary of Medical Sciences gave him the opportunity (1845) of writing an essay on this subject, which, even to-day, may serve as a model. His thoughts turned in this Paper to one of the most important physiological questions relating to the nature of vital power: whether the life of organisms be due to a peculiar self-producing purposeful power, or is the result of forces acting also in inorganic nature. He examined the material exchanges of muscular action, and found that the substances contained in muscle soluble in water were diminished in quantity by muscular activity, whereas those extracted by alcohol were increased in amount, so that "a chemical change occurs in compounds contained in it." He expected at that time that a deeper comprehension of these processes would result from further investigations; and yet to-day the highly developed state of physiological chemistry is unable to give a clearer answer to the question. In near relation to this, he proved (1847) that muscles give out heat during activity.

In the same year, in a small pamphlet on "The Conservation of Energy," he gave a vigorous proof of the following proposition:—"In all cases of the motion of free material points under the influence of attracting and repelling forces whose intensity is solely dependent on the distance [the loss in potential energy is always equal to the gain in kinetic energy, and the gain in the former is equal to the loss of the latter, so that] the sum of the kinetic and potential energy is always constant." From this it follows that no energy is lost in the world, but that it alters only in its mode of manifestation, so that, for instance, chemical affinity can be converted into heat or electricity, this latter into heat or motion of masses, &c. At the same time, he showed that all the processes of Nature obey the laws of mechanics. Previously to this, heat had always been regarded as a "substance." Helmholtz showed "that the phenomena of heat can all be looked upon as motion." With this he brought science on to a plain path. But at first he met with opposition from authorities on the subject. His article was rejected by *Poggendorff's Annalen*, and amongst the members of the Berlin Academy only Jacobi, the mathematician, espoused his cause. Even when his fame penetrated through wide circles, doubt was thrown on the originality of this epoch-making work. Helmholtz had written his pamphlet in ignorance of the work of Robert Mayer (1842 and 1845). When still in the third form of the gymnasium of Potsdam, he had found it perplexing to reconcile the experiments of Rumford and Humphry Davy on the production of heat by friction with the then orthodox conception that heat was an imponderable substance. What wonder, then, that as a fully developed mathematician and physicist he should recognise that the "heat resulting from friction is to be looked upon as the apparently lost *vis viva*?"* Helmholtz readily acknowledged the priority of Joule and R. Mayer even before it was claimed, and was the first to bring into prominence the merits of the doctor of Heilbronn in the discovery of the great new universal principle.

But how far above his predecessors he was! R. Mayer's first essay gives no *proofs*, but only sets forth theses, and even in his more detailed article on "Organic Motion in its Relation to Metabolism" (1845) he supports only by general, although extremely ingenious, arguments his axiom that "in all physical and chemical processes the given energy remains a constant magnitude" (p. 32), and further, "in vital processes there is only a transformation of matter as well as energy, but never any creation of either the one or the other" (p. 40). Mayer, too, on even the most suitable occasions, does not mention his immediate predecessor Joule. In how different manner do the trained

* Lectures and Speeches. Vol. I., p. 66.

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physicist and speculative doctor treat the same subject! Helmholtz proved experimentally the increased consumption and increase of heat during muscular activity. Mayer affirmed —without proofs—that every casual movement took place with the formation of carbonic acid and water; that "every muscle whose supply of atmospheric air is cut off ceases from its activity" * (p. 87). "With every muscular action, heat *in statu nascente* is set free" (p. 94). "In continued work there is a summation of this loss of heat which can be detected by observation" (p. 95). "A clever smith can bring a cold piece of iron to red heat by hammering; but this temperature is made at the expense of the temperature of his arm. *Ex nihilo nihil fit*" (p. 96).

Helmholtz calmly followed his own lofty path, as teacher of Anatomy in the Academy of Art in Berlin, and assistant in the anatomical museum; he succeeded one of his friends occupied in the same pursuits, namely, Brücke, and found another, E. du Bois Reymond, still with his teacher, Johannes Müller. In the following year, Helmholtz was called to Königsberg as Professor of Physiology and General Pathology. "General Pathology was looked upon by the ancients as the finest flower of medical science. But what formerly made up its contents has only historical interest for the disciple of modern science." It was on dogmas that the fundamental views of medicine were then based. Helmholtz was always an enemy of the deductive method. "The fact of a conclusion being drawn by the most accurate and logical methods from an uncertain premiss does not add a hair's breadth to its certainty or value." Many old physiologists considered it beneath their dignity to make experiments, but Helmholtz always maintained, in contradiction to the metaphysicians, that "it is the duty of scientific research to seek the laws governing disconnected facts." How fruitful were his methods is shown by his researches at Königsberg, in in the first of which, in 1850, he determined the duration of muscular contraction and the rate of transmission of nervous impulses.

(To be concluded.)

REVIEWS.

Der Betrieb und die Schaltungen der Elektrischen Telegraphen. 3 vols. By Dr. KARL EDUARD ZETZSCHE. (Halle a-S: Wilhelm Knapp.)

The present volume, "The Working and Connecting of Electric Telegraphs" is supplementary to the Doctor's well-known "Handbook of Electric Telegraphy," &c., and is a carefully compiled and well-illustrated work, dealing with everything of note or interest appertaining to telegraphy. G. B. Prescott in his "Electricity and the Electric Telegraph (1881)," says, "special attention has been paid to the voluminous contribution of Germany, a nation whose electricians unquestionably occupy the foremost rank among discoverers and inventors, but whose labours, although lying at the foundation of many of the most brilliant achievements of modern telegraphy, have heretofore remained for the most part unknown to the English reader." Dr. Zetzsche, however, by no means confines himself to the achievements of his own countrymen, his book being both comprehensive and cosmopolitan. Dr. Zetzsche has proved himself a most careful compiler of information relating to the different systems and instruments in use for land line and submarine telegraphy. The letter-press is clear and the illustrations numerous.

The first part of Vol. I. deals with keys and instruments; the second part with the use of these, and the circuits and connections for simplex and duplex working, electrical disturbances in cables, &c. In Vols. II. and III. the systems and connections for simplex telegraphy are further explained and illustrated, as well as those for "duplex" on short lines, long aerial lines, and for cables. Explanations are also given of the duplex, quadruplex, and multiplex. Towards the end of the last volume the author makes some judicious observations on the proper mode of training and the requisites of good telegraphists. Dr. Zetzsche's latest work is certain to attain the same popularity that his previous efforts have met with in Germany and elsewhere.

* Johannes Müller confirmed (1833-1837) already, in the older editions of his celebrated text-book, the observations of Spallaazani, that cold-blooded animals continue to expire carbonic acid even in an atmosphere free from oxygen. Burdach says the same of warm-blooded animals in his "Physiology" (1835), Vol. V., p. 375.

ELECTROMAGNETIC THEORY.—XIV.

BY OLIVER HEAVISIDE.

(Continued from page 354).

§ 77. To further exemplify the significance of the electric stress, let us introduce a foreign body into a stationary electric field. The field will be disturbed by its introduction, and will settle down to a new state; the change depending upon the nature of the foreign body, whether conducting or non-conducting, in substance or superficially, and upon whether it has a charge itself, or contains any other source of displacement. If it be a good conductor, either charged or uncharged, the final state, reached very quickly, will be such that the displacement will terminate normally upon its surface, thus reproducing the previous case (§§ 74 to 76). But if it be a non-conductor, the result is somewhat different. If superficially conducting, we may indeed have an ultimate electrification of the surface, so as to come wholly or partly under the same case: but if there be no superficial or internal conduction, or only so little that a long time must elapse for it to become fully effective, what we do is simply to replace the dielectric air in a certain region by another dielectric of different permittivity, usually greater. Then, supposing the external field to be due to charges upon insulated conductors or to internal electrification in the air (kept at rest for the purposes of the argument), no change will occur in their amounts; but there will be merely an alteration in the distribution of the electrification on the conductors, caused by the displacement becoming denser within the foreign body than before (or less dense, if its permittivity can be less than that of the air). The intrinsic electrification of the body itself, if any, must also be allowed for; but should it have none previously, it will remain unelectrified when introduced into the field, and the displacement will pass freely through it, and out again in a solenoidal manner. This is expressed by the surface condition

$$\mathbf{D}_1\mathbf{N}_1 + \mathbf{D}_2\mathbf{N}_2 = 0,$$

where $\mathbf{D}_1$ and $\mathbf{D}_2$ are the displacements in the air and foreign body respectively at their interface, and $\mathbf{N}_1$, $\mathbf{N}_2$ are the unit normals from the interface to the two media.

The only quite simple case (excepting that of infinite plane sheets) is that of a sphere of uniform permittivity brought into a previously uniform field. The ultimate displacement in the sphere is then parallel to the original displacement in the air. It may vary between zero and three times the original displacement, as the permittivity of the sphere varies from zero up to infinity. It is certainly a little surprising that the ultimate displacement with infinite permittivity should be only three times the original (and it is not much less when the permittivity is only 10 times that of the air); whilst, on the other hand, the zero displacement when the permittivity is zero (a quite ideal case) is obvious enough, because the displacement never enters the sphere at all, but goes round it. The original uniform field may be conveniently that between the parallel plates of a very large air condenser. There is, however, a double action taking place. When the transverse voltage of the condenser is maintained constant by connection with a suitable source, the insertion of the foreign body will increase or reduce the permittance of the condenser, and so increase or reduce its charge under the action of the constant source, besides concentrating the displacement within itself, or the reverse. With constant charges, however, when the plates are insulated, the insertion of the foreign body will reduce the transverse voltage when its permittivity exceeds that of the air; and conversely. Increase of permittivity also increases the stored energy when the transverse voltage is constant, but reduces it when the charges are constant.

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Now, since the electric force does not terminate on the boundary of the foreign body, but extends all through it, so does the electric stress. So far, however, as the resultant force and torque on the body, when solid, is concerned, we may ignore the internal stress altogether, aad consider only the external, or stress in the air. This is a particular case of a somewhat important and wide property in abstract dynamics, which we may state separately thus.

§ 78. The resultant force and torque due to any stress in any region is zero. Or, any stress in any region forms a self-equilibrating system.

Imagine any distribution of stress to exist in a region A, and to terminate abruptly on its boundary. Or, equivalently, imagine a piece of a stressed solid to be removed from its place without altering the stress. The stress-variation, when estimated in a certain way, constitutes mechanical force tending to move the body. This will be in the case of an ordinary irrotational stress, entirely translational force. But there are two kinds. First, there is internal force, reckoned per unit volume, due to the continuous variation of the stress in the body. Next, there is superficial force, reckoned per unit area, due to the abrupt cessation of the stress. This surface traction is represented simply by the stress vector itself, acting on the inner side of the surface of the body. Now, the resultant effect of these two forcives, over the surface and throughout the volume of the solid respectively, in tending to translate and rotate it, is zero. Or, in other words, the force and torque equivalent to the surface forcive are the negatives of those due to the internal forcive. If it were otherwise, the differential action would cause indefinite increase in the translational and rotational energy to arise out of the internal mutual forces only of a body.

If the stress be of the rotational type, there will be an internal torque (per unit volume) as well as a translational force. Still, however, the resultant force and torque due to the surface tractions will cancel those due to the internal forces and torques.

In case there be any difficulty in conceiving the traction exerted on the surface of a body by the stress within itself, we may replace the sudden cessation of the stress by a gradual cessation through a thin skin. The solid is then under the influence of continuous bodily force only (and torque also, if the stress be rotational) conveniently divisible into the internal force all over, and the force in the skin. Otherwise it is the same.

Now put the solid piece back into its place again. Since its own stress balances itself, we see that whatever the forcive on the piece may be it must be statically equivalent to the action upon its boundary of the external stress only, constituting an external surface traction. There need be no connection between the external and the internal stress. The latter may be anything we like, so far as the resultant force and torque on the piece are concerned. The difference will arise in the strains produced, or in the relative internal motions, when for one stress another is substituted.

§ 79. Returning to the electric field, we see that whatever be the nature of the reaction of the foreign body on the original state of the field, the resultant mechanical action on the body as a whole is fully represented by the stress in the air just outside it, in its actual state, as modified by the presence of the body, and that we need not concern ourselves with the internal state of stress. Nor are we limited, in this respect, by any assumed proportionality of electric force to displacement in the body, or assumed absence of absorption, or other irregularities and complications. That is, we need not have any theory to explicitly account for the change made in the electric field by the body. Nor do we gain any information regarding the internal stress from merely a knowledge of the external stress, although that involves the reaction of the body on the electric field. This is the meaning of the statical indeterminations of the stress before referred to, and the principle applies generally.

The air stress vector **P** will usually have both a normal and a tangential component at the surface of a body, viz.:—

$$\begin{aligned} &\mathrm{U}\cos 2\theta \quad \text{normal,}\\ &\mathrm{U}\sin 2\theta \quad \text{tangential,}\end{aligned}$$

if θ be the angle between the normal **N** to the surface (drawn from the body to the air) and the electric force **E**, and U the density of the electric energy, or the tensor of the stress vector.

In only one case, however, will this external surface traction represent the real forcive in detail (as well as in the lump), viz, when there is no stress at all on the other side of the boundary, that is, in the case of a conductor in static equilibrium. In general, the real surface force is represented by the vector $\mathbf{P}_1 - \mathbf{P}_2$, the stress difference at the boundary, $\mathbf{P}_1$ being the external and $\mathbf{P}_2$ the internal stress vector, which two stresses may, if we please, be imagined to be united continuously by a gradually changing intermediate stress existing in a thin skin, an idea appropriate to molecular theories. (It may be remembered that **P** when positive means a pull.) Each of these may be split into a normal and a tangential component. Now, the tangential components are

$$\mathrm{U}_1 \sin 2\theta_1 \text{ and } \mathrm{U}_2 \sin 2\theta_2,$$

where the suffix $_1$ relates to the air, and $_2$ to the other medium.

Or $$\mathrm{E}_1\mathrm{D}_1 \sin\theta_1\cos\theta_1 \text{ and } \mathrm{E}_2\mathrm{D}_2 \sin\theta_2\cos\theta_2.$$

But here we have normal continuity of the flux **D**, and tangential continuity of the force **E**; (otherwise the surface would be electrified and covered with a magnetic current sheet); that is

$$\left.\begin{aligned} \mathrm{D}_1\cos\theta_1 &= \mathrm{D}_2\cos\theta_2,\\ \text{and}\quad \mathrm{E}_1\sin\theta_1 &= \mathrm{E}_2\sin\theta_2,\end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (5)$$

These relations make the tangential tractions equal and opposite, so that there is no resultant tangential traction, and the actual traction is entirely normal, being the difference of the normal components of $\mathbf{P}_1$ and $\mathbf{P}_2$, or,

$$\mathrm{U}_1\cos 2\theta_1 - \mathrm{U}_2\cos 2\theta_2, \quad . \quad . \quad . \quad . \quad (6)$$

which is the same as (being subject to (5),

$$\begin{aligned} &\tfrac{1}{2}\,\mathrm{D}_1\cos\theta_1\,(\mathrm{E}_1\cos\theta_1 - \mathrm{E}_2\cos\theta_2)\\ &-\tfrac{1}{2}\,\mathrm{E}_1\sin\theta_1\,(\mathrm{D}_1\sin\theta_1 - \mathrm{D}_2\sin\theta_2) \quad . \quad . \quad . \quad (7)\end{aligned}$$

The coefficient $\frac{1}{2}$ comes in for a similar reason to before, § 75.

This formula (6) or (7) being the real surface traction when **E** varies as **D** in the body, and the stress is of the same type as in air, furnishes a second way of calculating the resultant force and torque on the body, when its permittivity is uniform; and it is noteworthy that the surface traction is, as in the case of an electrified conductor in equilibrium, entirely normal, although it may now be either a pull or a push.

§ 80. Noting that the mechanical force on the elastically electrizable body is situated where the change of permittivity occurs, and is in the direction of this change, it may be inferred that when the permittivity varies continuously there is a bodily translational force due to the stress variation which is in the direction of the most rapid change of permittivity. This is, in fact, what the stress vector indicates when c varies continuously, viz., the force represented by

$$-\tfrac{1}{2}\mathrm{E}^2\nabla c = -\nabla_c \mathrm{U}, \quad . \quad . \quad . \quad . \quad . \quad (8)$$

where ∇c means the vector rate of fastest increase of c roundabout the point considered. Since $\mathrm{U} = \frac{1}{2}c\mathrm{E}^2$, the second form in (8) will be understood, meaning the vector slope of U as dependent upon the variation of c only.

This bodily force, and the previous surface force may be harmonised by letting c vary not abruptly, but continuously from the value c_1 on one side to c_2 on the other side of the surface of discontinuity, through a thin skin, and summing up the translational forces in the skin by the formula (8). Thus, if x be measured normal to the skin, the translational force per unit volume is $-\frac{1}{2}\mathrm{E}^2\,(dc/dx)$ in the direction of the normal; or

$$\begin{aligned} &-\tfrac{1}{2}\,\mathrm{E}_n^2\frac{dc}{dx} - \tfrac{1}{2}\,\mathrm{E}_t^2\frac{dc}{dx}\\ &= -\tfrac{1}{2}\,\mathrm{D}_n^2\,\frac{1}{c^2}\,\frac{dc}{dx} - \tfrac{1}{2}\,\mathrm{E}_t^2\frac{dc}{dx}, \quad . \quad . \quad . \quad (9)\end{aligned}$$

where E_n and D_n are the normal components of **E** and **D**, and E_t the tangential component of **E**. Now D_n and E_t are constant ultimately, for the reason before given, so we can integrate (9) with respect to x immediately, giving

$$\left[\tfrac{1}{2}\frac{\mathrm{D}_n^2}{c} - \tfrac{1}{2}c\mathrm{E}_t^2\right] = \left[\tfrac{1}{2}\,c\mathrm{E}_n^2 - \tfrac{1}{2}\,c\mathrm{E}_t^2\right] \quad . \quad . \quad (10)$$

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between the limits; or, since E_n and E_t are proportional to the cosine and the sine of θ respectively.

$$[\tfrac{1}{2} cE^2 \cos 2\theta]$$

between the limits, which is the same as (6), which was to be verified.

§ 81. Since a sphere of uniform permittivity placed in a uniform field causes the external lines of electric force to be symmetrically distorted fore and aft, it has no tendency to move, but is merely strained. But if the body be not in an initially uniform field, or be not spherical, complex calculations are usually needed to determine the effect. If, however, it be only a small piece, the tendency is for it to move in the direction in which the energy, or the stress, in the field increases most rapidly, independent of the direction of the electric force, when its permittivity exceeds that of the gaseous medium. The total electric energy will be diminished by permitting the motion when the charges are constant; but increased should the field be kept up by constant sources of voltage.

These properties are rendered particularly evident by taking the extreme cases of infinite and zero permittivity of a small body placed in a widely varying field, that surrounding a charged sphere, for example, the electric force varying in intensity as the inverse square of the distance from its centre. Here the non-permittive body is repelled, for the lines of force go round it, and the lateral pressure comes fully into play, and is greater on the side next the charged sphere. On the other hand, with the infinitely permittive body, concentrating the displacement, it is the tension that comes fully into play, and this being greater on the side next the charged sphere, the result is an attraction. The permittance of the sphere, also, is increased in the latter case, and decreased in the former—that is, when the natural motion of the body to or from the sphere is allowed; so, since the total electric energy is $\frac{1}{2} SV^2$ where S is the permittance and V the voltage, or, equivalently, $\frac{1}{2} VQ$, if Q is the charge, we have always a diminution of energy when the natural motion is allowed, whether resulting from attraction or repulsion, if the charge is constant; but an increase of energy if the voltage is constant.

In intermediate cases the tension is dominant when the c of the body exceeds, and the pressure is dominant when it is less than that of the air, there being perfect equilibrium of a piece of any shape in any field if there be equality of permittivity, and therefore no disturbance of the field. Here we see the part played by the lateral pressure in the case of conductors in equilibrium. It has no influence on them immediately, and might be thought wholly unnecessary, but it is equally important with the tension in the non-conducting dielectric itself.

§ 82. Passing now to the corresponding magnetic side of the stress question, we may observe that the analogy is an imperfect one. Thus, proceeding as at the beginning of § 74, to have a stationary magnetic field without impressed forces, we shall find that there must first be no magnetic conduction current; and next, that the gaussage in any circuit must be zero. The magnetic force we then conclude to be confined entirely to the magnetically non-conducting regions, and to terminate perpendicularly upon their boundaries. Then we come to the conception of a number of detached magnetic conductors immersed in a magnetically non-conductive medium, these conductors having magnetic charges on them measured by the amount of induction leaving or terminating upon them, with possible associated volume magnetification in the non-conducting medium.

The magnetic stress will exert a normal traction

$$\mathbf{NT} = \tfrac{1}{2}\mu \mathrm{H}^2 \mathbf{N} \quad . \quad . \quad . \quad . \quad . \quad (12)$$

per unit area on the conductors, and a force

$$\mathbf{H}\sigma = \mathbf{H} \operatorname{div} \mathbf{B} \quad . \quad . \quad . \quad . \quad . \quad (13)$$

per unit volume on tridimensional magnetification, of density σ, measured by the divergence of the induction. These are analogous to the forces on surface and volume electrification.

Also, when the inductivity μ varies, we shall have a normal surface traction of amount,

$$T_1 \cos 2\theta_1 - T_2 \cos 2\theta_2 \quad . \quad . \quad . \quad . \quad (14)$$

per unit area, analogous to (6), when μ changes value abruptly at the interface of two media; and a force

$$-\tfrac{1}{2}\mathrm{H}^2 \nabla\mu \quad . \quad . \quad . \quad . \quad . \quad . \quad (15)$$

per unit volume, when μ varies continuously.

The forces (12), (13), however, are absent, because of the absence of magnetic conductivity, and, in connection therewith, the absence of "magnetification." But (12) may be sometimes used, nevertheless, when it is the stress across any surface that is in question, and we create surface magnetification by regarding one side only.

We are, therefore, left with the forces (14), (15), depending upon variation of inductivity, abrupt or gradual. These explain the mechanical action upon elastically magnetised media, *e.g.*, the motions of bodies to or from a magnet pole, according as they are paramagnetic or diamagnetic, which, it should be remembered, depends fundamentally upon the variation in the intensity of magnetic force near the pole; and the axial equilibrium of a paramagnetic bar, and equatorial equilibrium of a diamagnetic bar. Faraday's remarkable sagacity led him to the essence of the explanation of these and other allied phenomena, as was later mathematically demonstrated by Sir W. Thomson. Questions relating to diamagnetic polarity are, in comparison, mere trifling.

(To be continued.)

THE FRANKFORT EXHIBITION.—VII.

(FROM OUR SPECIAL CORRESPONDENT.)

In a side division of the Hall for the Distribution of Electricity, the Allgemeine Electricitäts Gesellschaft have set up a small model plant on the so-called rotary current system. As

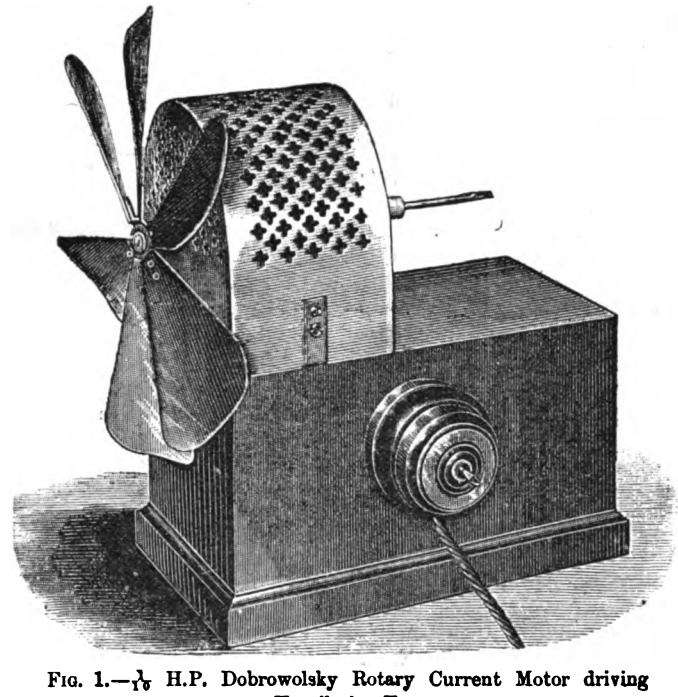

FIG. 1.—$\frac{1}{10}$ H.P. Dobrowolsky Rotary Current Motor driving Ventilating Fan.

the principle of the system has been recently fully explained in *The Electrician* (August 7th), I need not enlarge upon it here. The model plant comprises two motors, the first being a $\frac{1}{10}$ H.P. motor, driving a ventilating fan (Fig. 1). The second motor (Fig. 2), is of 2 H.P., but will take a load of 4 H.P. without perceptibly slowing down. It runs normally at about 1,800 revolutions. The current driving these two motors is supplied from a machine which is driven by continuous current supplied from an Oerlikon dynamo in the Machine Hall. Directly coupled to the 4 H.P. motor is a continuous current dynamo, running a number of glow lamps arranged in multiple arc. The motor is wound for 70 volts, with 30 Ω. It starts at full load

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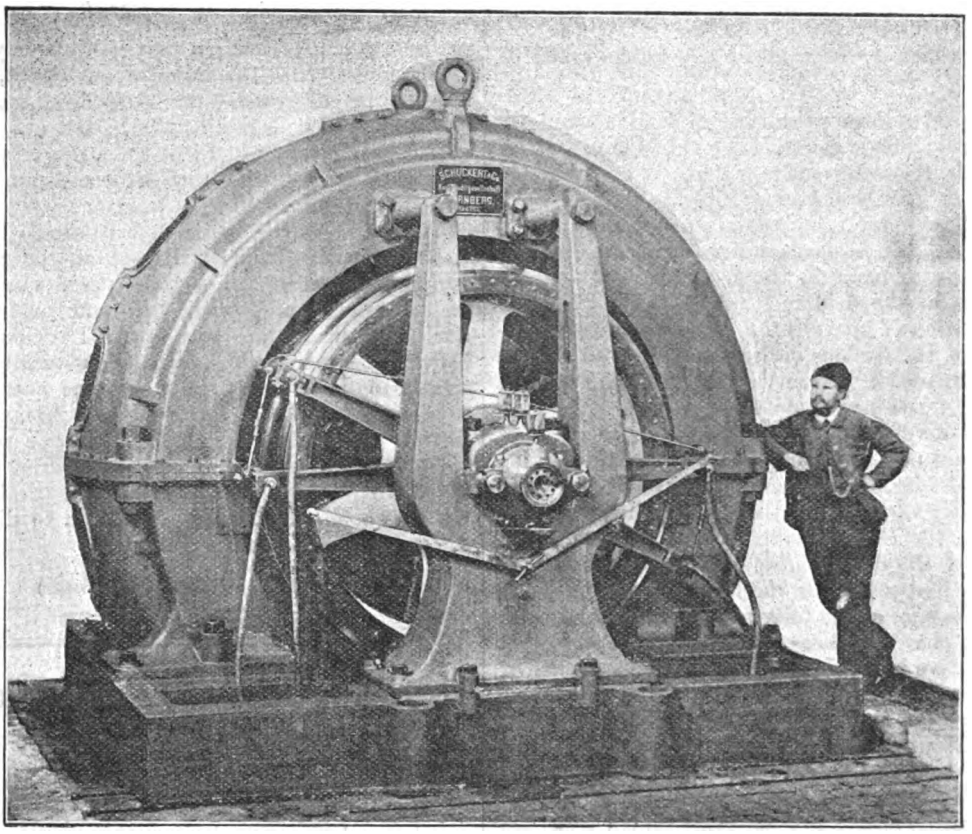

FIG. 3.—Shunt-wound 230-Kilowatt Schuckert Dynamo.

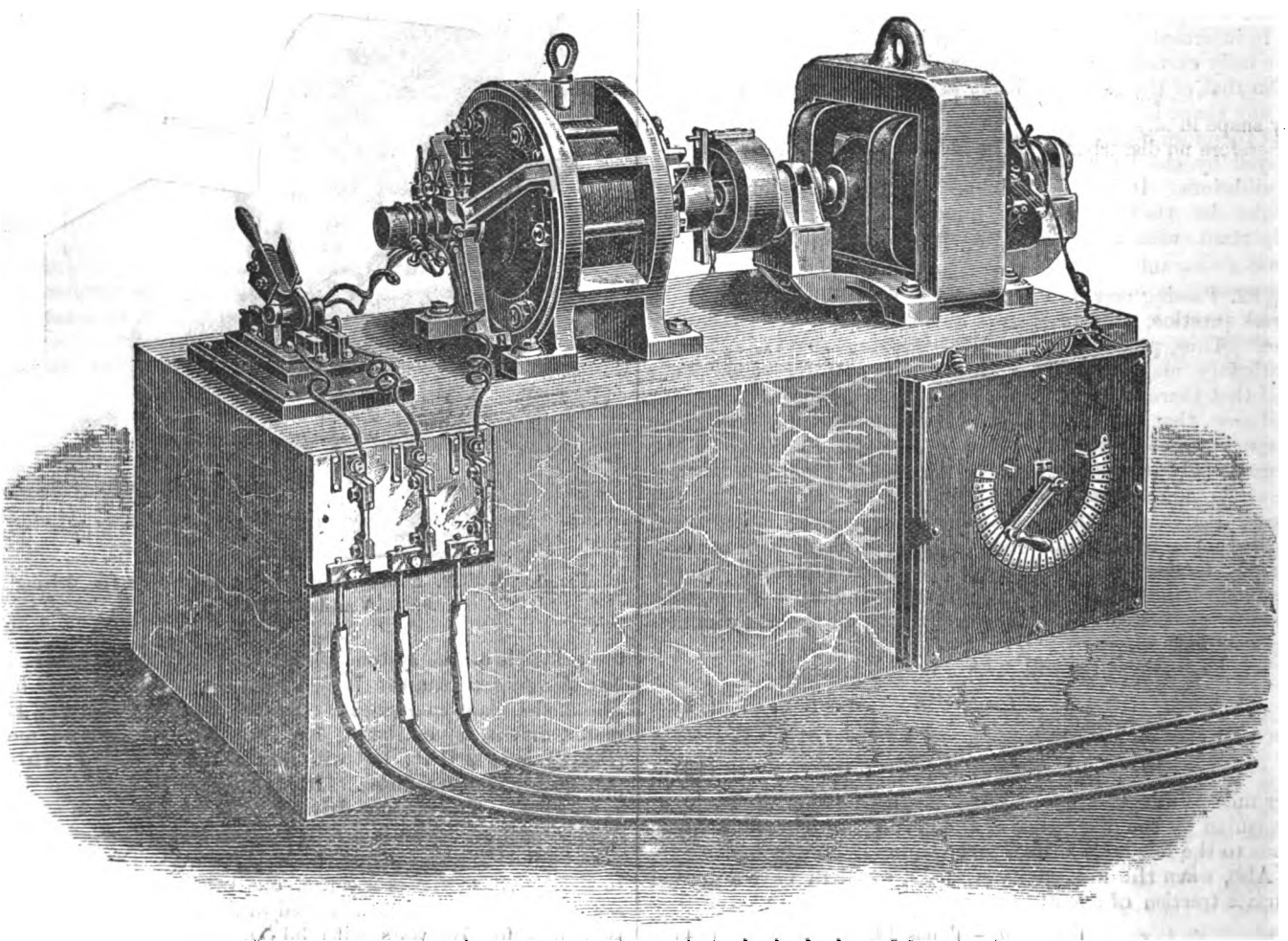

FIG. 2.—2 H.P. Dobrowolsky Rotary Current Motor driving Continuous Current Dynamo.

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and, like the others, it has the advantage over ordinary alternating motors that it is not suddenly stopped when over-loaded; Its commercial efficiency when running at normal load is said to be as high as 82 per cent.

The Schuckert dynamo is almost as well known in England as in Germany, where it has gained a great reputation by reason of its good workmanship and solidity of construction Since its first introduction the Schuckert type has naturally been considerably modified, and the machines shown at Frankfort contain all the numerous improvements suggested by long experience. The field-magnets are now made shorter and of larger cross-section, and the machines have as few parts as possible; the bearings are large, and the armatures carefully balanced. In Fig. 3 is shown the largest dynamo exhibited. It is a shunt machine coupled direct to a 320 H.P. steam engine by Kuhn, of Stuttgart-Berg, running at 160 revolutions. On each side of the Gramme ring armature are 14 pole pieces. The iron forming these 28 poles is cast in four parts, which are bolted together, and enclose the whole machine, openings round the

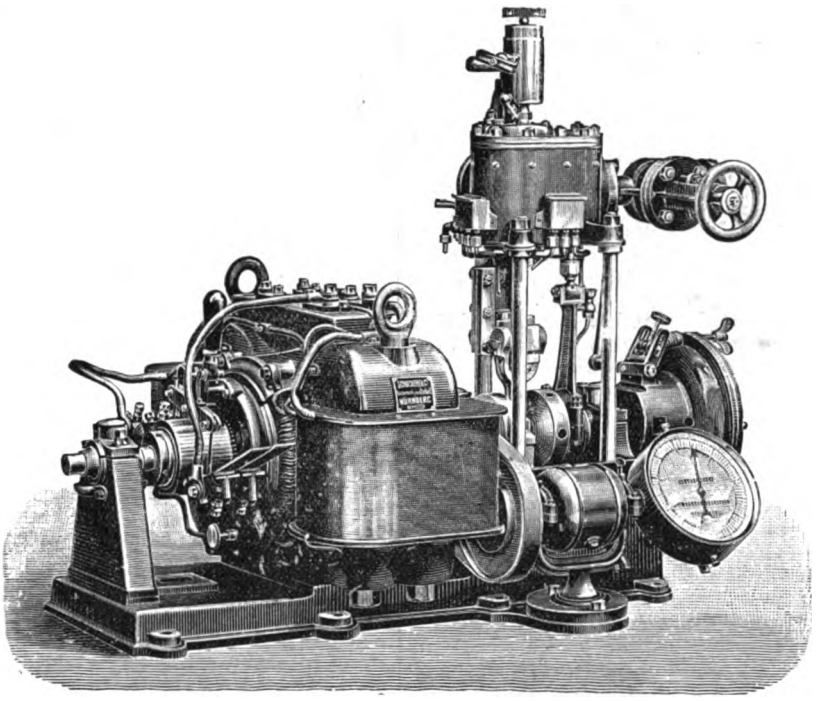

Fig. 4.—Schuckert Ship-Lighting Plant.

casing giving sufficient ventilation for the armature. When it is necessary to examine or repair the armature the top half of the frame is unbolted from the lower, and simply raised up above, leaving the armature bare. The cast-iron frame is bolted to the bed-plate of the machine, from which rise the supports for the armature bearings. These supports are forked round the bearings and prolonged above them, where they meet horizontal pieces from the frame to which they are bolted. The armature is made of laminæ of the very best soft Swedish iron.

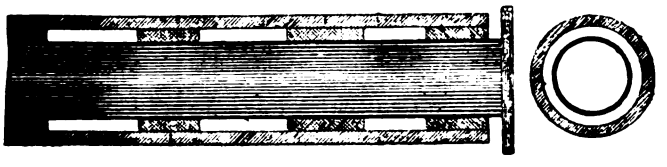

Fig. 5.—Emmerling System of Steam Pipe Lagging.

The diameter of the armature is 7ft. 10½in., and that of the 560 part commutator 4ft. 11in. The output at full load is 1,000 amperes and 230 volts. The weight of the machine is about 22 tons. Two other smaller machines of the same type are also shown by Schuckert and Co. One of these is of 200 H.P., and has been specially built for transmission of power purposes. The 200 H.P. machine weighs about 18 tons. Large machines of the same make as the dynamo first described, and of 350 kilowatts each, have been supplied to the Hanover Electricity Works (15,000 glow lamps), Altona (15,000 glow lamps), and Düsseldorf (20,000 glow lamps). In Fig. 4 is shown a small ship lighting plant designed by this firm, the steam engine being by Daevel, of Kiel.

Among the many different systems of steam pipe lagging to be seen at the Exhibition, that of Emmerling, of Nuremberg, seems worthy of notice. The material is composed of a mixture of cork and tar, and is subjected to great pressure and high temperature in the course of manufacture. The substance is arranged in such a way as to leave air spaces at intervals along the pipe to be covered, in the manner shown in the accompanying sketch (Fig. 5). The cork and tar mixture is put on in two portions. The outer portion runs in a continuous strip along the whole length of the pipe, and the inner portion is put on in rings at short intervals. The outer covering is in 20in. lengths, and the joints are always made at the middle of one of the interior rings, which are each about 2in. broad. The air space left in every 20in. of pipe length amounts to 16in. The thickness of the inner rings is 1in. The air thus confined in the spaces all along the pipe gradually takes the temperature of the steam pipe, and, since it is stagnant, it forms an admirable non-conductor. The lagging material, moreover, does not absorb moisture, and is unaffected by variations of temperature. The material is largely used in the Exhibition.

NOTE ON SOME LATELY MANUFACTURED TELEPHONE CABLES.*

BY FREDERIC A. C. PERRINE.

We are constantly using the telephone over both long and short circuits, and it is largely from the telephone "expert" that the modern electrical engineer was developed; yet to-day there is no department in electrical engineering concerning which accurate knowledge is so little diffused and difficult to obtain as that of the details of a telephone exchange, the requirements of the instruments, the switchboard, and the line. The electrical measurements of the lately-opened London and Paris telephone line were published in all the journals, and a report of the tests with the different instruments; but to a majority of our electricians these data afforded little basis for comparison.

In England to-day, and within a few years, in this country, a well-insulated line meant invariably one in which the wire is covered either with rubber or gutta-percha, and, except in long submarine

* From the *Electrical World* of New York.

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cables, little attention was paid to the retardation due to capacity. Accordingly, on the introduction of the telephone, by reason of the multiplication of wires, and the consequent demand for underground circuits, cables were made and laid of rubber and gutta-percha-covered wire. In spite of every precaution it has been found impossible to keep the gutta-percha from oxidising unless laid under water and in the dark. The rubber cables have stood better, but in these, as they were originally made, two defects have developed, and one has proved insurmountable. In the first place, on account of the parallel laying of the conductors, in spite of the highest insulation, it was possible to talk from one wire to another by static induction. This defect was readily overcome by using an entirely metallic circuit, and twisting together the two wires composing it into pairs, but the second defect has been found to be one inherent in the use of any solid insulation, such as a gum-like gutta-percha or rubber. On account of the high specific inductive capacity of these materials, it is found that a retardation of the electrical waves is produced which soon muffles and finally effaces entirely all articulate speech.

Investigating this phenomenon, Prof. Jacques, of Boston, has found that for a Blake transmitter the limit of speaking is reached when the product of the resistance by the capacity of the line reaches 2,000, and for the long distance or Hunnings transmitter the limit is reached when this product becomes 4,500. Of course beyond these limits experts can do some talking, and Mr. W. H. Preece places the latter figure at 6,000. But the figures of 2,000 and 4,500 represent more nearly the limits in every-day practice.

In the case of any telephone cable, therefore, the requirements are a low-conductor resistance, and at the same time the lowest static inductive capacity. These requirements are necessarily limited by the mechanical construction due to the size of the ducts available and the cost of manufacture. In all of our cities subways have been laid having ducts from 2in. to 3in. in diameter, and, in consequence, cables must be made of diameters not exceeding 2⅝in., and, indeed, it is preferable that a diameter of 2¼in. be not exceeded for a 3in. duct, or 2½in. for a 2½in. duct., on account of the necessary internal irregularities of the iron pipe.

Now, taking these external dimensions, it has been found that if the conductors be insulated each to one-eighth of an inch, then in the 2¼in. cable 60 pairs can be nicely laid, allowing one-eighth of an inch for the thickness of the lead, and in the 2½in. cable it is possible to lay 83 pairs, allowing in each of these one extra pair for possible defects in manufacturing or laying. These cables have been adopted as the standard in size and insulation, and the next question to be settled has been the size of the conductor.

No consideration of heating is here necessary, and the loss of potential on account of the resistance is also a small factor in comparison to the retardation from the high capacity. The use of the finest sizes of wire has been found inadvisable on account of the difficulty of manipulation in manufacturing and splicing in the manholes. No. 18 B. and S. gauge soft copper wire, with a maximum resistance of 36 ohms per mile, was accordingly adopted, and has been the standard for several years. By reason of the rapid extension of the telephone exchanges in cities, and the consequent small importance of the resistance of the cables, the size has been reduced, at the last Telephone Conference, one gauge, and now stands at No. 19 B. and S. with a maximum resistance of 46 ohms per mile.

With the external diameter; the diameter of the insulation and the diameter of the conductor all fixed, the problem presents itself that the insulating material be used which will secure the lowest capacity, and hence the best circuit for talking. Dense gums, such as rubber and gutta-percha, as we have said before, give, with the cable indicated, a capacity of ·3 microfarads per mile, or the equivalent of 110 miles of pole line, composed of No. 12 B. and S. hard drawn copper wire, strung 36ft. in the air. Besides, both the great cost and unreliability of these materials render their use undesirable. The first advance that was made was the use of cotton artificially dried and saturated with paraffin. By this means, capacities from ·2 to ·18 have been obtained, and this, with the cotton and resin oiled cable led the Telephone Conference to reduce their specifications to ·18 demanded, or the equivalent of about 67 miles of pole line. The next step in advance was the use of dry cotton without any saturation whatever. Here a capacity as low as ·1 to ·11 was obtained, and the pole line length of a mile of cable reduced to 37. At about this time we commenced a series of experiments at the Roeblings', with a view of determining any possible lowering of this capacity still further, and as a result we have succeeded in making and laying two cables, one in Boston and one in New York, of No. 18 B. and S. wire, of which the capacities after laying are measured as ·082 and ·081 respectively, with a wire resistance of 33·6 ohms per mile, or, in the case of the New York cable, a retardation equivalent to 28 miles of pole line. With the smaller sized wire lately specified this retardation should be reduced at least 5 per cent. By reason of these high results, the last conference reduced its specifications to an average capacity of ·085 with a maximum of ·09.

With a cable such as we have laid in New York, the conductor resistance being about 33·6 ohms and the capacity ·081, the product of the resistance by the capacity is 2·7216 per mile, and through such a cable one could talk about 736 miles with a Blake transmitter, or about 1,650 miles with a Hunnings. This represents not only the best results obtainable in fair weather under the best conditions, as is the case with a pole line, but the every-day practice, whatever the weather. This consideration, together with the total absence of cross-talk, for which these cables are rigorously tested with a breaking induction coil, render the cable of to-day no longer a bugbear, but a comfort to both the manager of the telephone exchange and its subscribers.

THE FIELD TELEPHONE.*

In the usual forms of receiving telephones it has been the practice to polarise the core and diaphragm to the utmost possible extent. A novel form of telephone has, however, been recently devised by Mr. Stephen D. Field, of Stockbridge, Mass., which is both a receiver and transmitter, and in which the inventor proceeds in a directly opposite manner, aiming to have these parts as neutral as possible, though at the same time making use of a magnet of great strength.

This instrument, shown in the accompanying illustration (Fig. 1), is of the polarised type, in which the permanent magnet constitutes a practically closed magnetic circuit, and has an open electro-magnetic circuit in which the diaphragm is situated. These two magnetic circuits are so arranged relatively to each other that the currents flowing around the poles of the open electro-magnetic circuit will cause more or fewer lines of force to be deflected from the closed or practically closed magnetic circuit, owing to the peculiar reactionary effect of the currents in the coils of the electro-magnets.

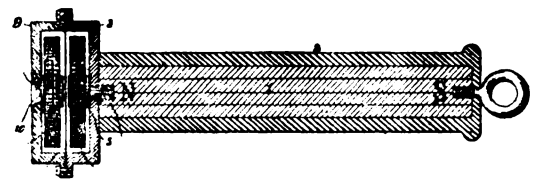

FIG. 1.—Field Telephone.

The action will be understood from the engraving, in which 1 represents a permanent magnet, made up of a number of separately magnetised steel bars. At the N-pole of this magnet is placed a cylindrical iron armature 3, attached to the magnet system by the core 5, whose projecting end is screwed into the magnet, and on which is mounted a helix, as shown. Across the face of the box armature is placed the diaphragm, which is held in position by the cover of the box. This cover carries on its inner face a projecting tubular core, on which is mounted another helix. The current flows in opposite directions in these two helices, as indicated by the arrows.

By this construction, two paths are opened for the lines of force from the magnet pole N; one by way of the walls of the case, with which the diaphragm is in direct contact, and the other by way of the cores 5 and 10. The latter path is broken by the space between these cores, and in this space the diaphragm vibrates. So far as concerns the cores, but very little polarity will normally be found between them in their adjacent ends, since the iron case forms a short circuit or "magnetic shunt" around them, and consequently the diaphragm will not be attracted toward one any more than toward the other by the mere influence of the permanent magnet.

Considering now that current-impulses are passing through the coils, the action will be as follows:—We will suppose that the current flows in the coil on the right of the diaphragm in such direction that it tends to induce S-polarity at the front end of core 5. Then a similar polarity will be developed in the front end of core 10. The lines of force will tend to circulate through the two magnetic circuits formed by the diaphragm and the sides of the iron box. Those lines due to the magnetisation of core 5 will tend to flow (*see* Fig. 2) from the end of the core through the box to the diaphragm, and through the diaphragm to and through the air-space between it and the core 5. These lines of force will be opposed in the air-space by the lines flowing through the air-space due to the permanent magnet, but the lines due to the other coil will proceed from the end of the core to the side of the box, to the diaphragm, to the air-space, and back to the end of the core. These lines will be assisted in the air-space by the lines from the permanent magnet, but will oppose the flow of the latter through the box, and the lines from both sources will pass in multiple arc through the diaphragm.

* From the *Electrical Engineer* of New York.

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The lines of force due to the permanent magnet will, therefore, follow the path through the box to the diaphragm, through the diaphragm to core 10, and through core 10 to the south pole of the permanent magnet.

It will, therefore, be seen that one core will be strengthened and the other will be weakened by any given current-impulse which circulates through their surrounding coils, and the diaphragm will, of course, be attracted by the stronger polarity. The amount of

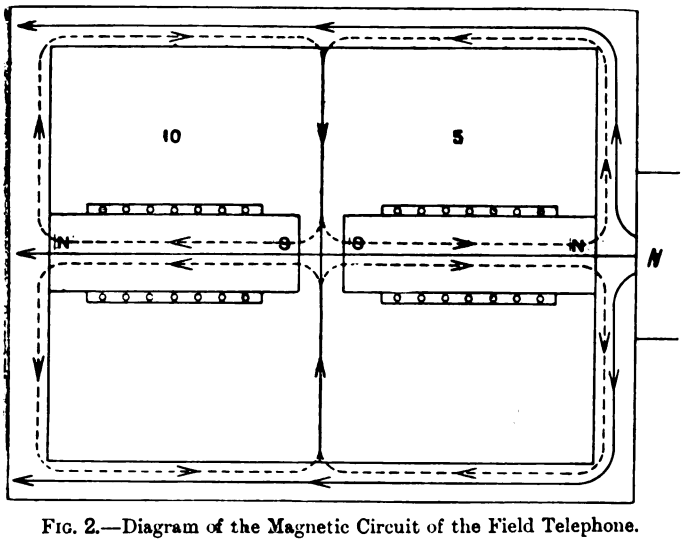

FIG. 2.—Diagram of the Magnetic Circuit of the Field Telephone.

this respective weakening and strengthening depends upon the current flowing. The result is a movement of the diaphragm toward one or other of the cores with a force dependent upon the strength of current used; and as the currents in the respective parallel coils flow in opposite directions, their inductive effects largely serve to neutralise their magnetic lag, so that the latter is quite unaffected by the strength of current flowing. In all cases the movement of the diaphragm is exceedingly sharp and prompt, whether the current used be very heavy or almost infinitely small.

THE ELECTRIC TRANSMISSION OF POWER.*

BY GISBERT KAPP.

LECTURE III.

(Continued from page 418.)

I have occupied some time in putting before you this transmission plant, because exact information about successful engineering work is of great value to practical men; and the Schaffhausen plant is certainly one of the best and most successful examples I could have chosen. The power transmitted is certainly large, according to our present ideas, but there is good reason to believe that—in point of magnitude, at any rate—this transmission will very soon be eclipsed by other work of this kind. There are projects afloat for utilising the power of the Rhine, near Bâle, to the tune of tens of thousands of horse-power, and at Niagara, as you all know, a total of 125,000 H.P., or a little over 3½ per cent. of the total power of Niagara, is to be taken from the Falls and transmitted to various distances, the longest distance being some 20 miles. I am not in a position to give you details of any of the schemes which have been submitted to the Niagara Commission, since these are the property of the Cataract Company, but, by the courtesy of several members of the Commission, notably Dr. Coleman Sellers, I am able to give you a general outline of the schemes. My object in applying to the Niagara Commission for information of this kind was to obtain some indication of the opinions which leading modern engineers entertain of electric power transmission, and to put the result of my inquiry before you. Lest the general condition of the Niagara scheme may not be quite familiar to all of you, I shall now throw upon the screen a picture of the Falls, and give you very briefly an outline of the objects for which the Cataract Company has been established.

Of the immense power represented by the descent of the river from its upper to its lower level over the Falls (about 3½ million H.P.), there is utilised at present an aggregate of only about 5,000 H.P. in the mills you see on the left of the picture. The water is brought to these mills by a surface canal from the upper reaches of the river, and, after passing through turbines, is discharged into the open air about half-way between the level of the ground and the level of the river below the tail races, forming a number of miniature waterfalls. Only about half the available head is therefore utilised. If the system adopted hitherto could be followed in future, there would be little difficulty in establishing a station for the generation of any amount of power in this locality, but there is a strong tide of public opinion against the establishment of any more hydraulic works on the river bank, to say nothing of the difficulty of finding room for them and the open-air canal which would be required. The Cataract Company have, therefore, resolved to carry out their operations, to a great extent, underground; and at the present moment are driving a tunnel 30ft. high by 20ft. wide, and about 6,700ft. long, which is to serve as a tail race for the water coming away from their power-station. This tunnel is shown on the picture by two dotted lines, and its mouth is partly submerged under the level of the lower river. The total fall between the upper and lower river is 200ft., and the net fall available for the turbines is 140ft. The fact that the tail race is a tunnel necessitates the turbines being placed at least 110ft. underground, since the suction tube of a turbine cannot be made longer than the column of water which can be balanced by atmospheric pressure, and this increases very materially the engineering difficulties of the work.

Last summer the Cataract Company invited a limited number of engineers to send in projects for the creation and transmission of power, and instituted a Commission, under the presidency of Sir William Thomson, to investigate and report on the projects. There were in all 20 competitors, but of these only 14 complied with the programme drawn up by the Commission, and were therefore held to be qualified to have their projects examined. Of these 14, eight competitors sent in combined projects for the creation and transmission of power, four referred only to the creation, and two only to the transmission of the power. The point of interest to us is what methods were suggested by the 10 qualified competitors in transmission. The question is somewhat complicated by the fact that some competitors have suggested mixed systems of transmission, and that, in classifying the schemes into electrical, pneumatic, and hydraulic, we must count some competitors twice over. On this basis I find that the following represents the transmission projects:—Electrical, 7; pneumatic, 6; hydraulic, 2. It is certainly remarkable that the balance in favour of electric transmission should be so small. And it is equally remarkable that there should have been as many as six competitors who either wholly or partially advocated pneumatic transmission. The experience of colliery managers goes to show that even over the comparatively short distances over which they use pneumatic transmission, the total efficiency lies generally between 20 and 30 per cent., and does certainly not exceed 40 per cent. We cannot suppose that engineers who have sent in pneumatic projects are ignorant of this fact, or, at any rate, we must suppose that the majority of them are quite aware that high efficiency cannot be expected from compressed air transmission. If, nevertheless, they have adopted compressed air in preference to electricity, it must be for one of two reasons. Either they have no confidence in the capabilities of electric transmission, or they consider the cost so high that the interest on the extra capital and the greater depreciation of the plant will more than counterbalance the advantage of high efficiency. It cannot be denied that, in the present state of our knowledge of electric transmission, there is some ground for both these views. The Niagara problem is unique, both in magnitude and distance, and I am bound to confess that we electrical engineers are at the present moment not quite prepared to face it. At the same time I must say that I feel convinced that in a few years from now there will be not one, but a dozen men ready to face this problem with a very good chance of successfully solving it. As a matter of fact, we are at present on the threshold of a new system of electric power transmission. The old system of using continuous currents and ordinary dynamos has been perfected to a point which leaves little to be desired, but it has its limits, and, unfortunately, the Niagara problem, or at least a part of it, is just a little beyond these limits. Hence we find that only about half of the competitors have had the courage to propose electric transmission. Of these, only two suggested the use of alternating currents at voltages of 5,000 and 10,000 respectively; the others followed the old lines of continuous current transmission at voltages varying between 1,600 and 4,500 volts.

This brings me to the consideration of a subject which is of great importance not only in regard to the Niagara problem but to long distance transmission generally, namely, the limits of distance up to which the usual system of transmission is practicable. If you will refer to the table giving the cost of transmission plants, given in my last lecture (*see ante* p. 710), you will find that, for large powers at any rate, an increase of distance up to four or five miles does not make the cost prohibitive, and you will conclude from these figures that, within a five mile limit, the whole system of electric

* Cantor Lectures delivered before the Society of Arts, February and March, 1891.

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transmission is certainly feasible. How much farther you might go is a matter for theoretical consideration ; the table does not help you much, as the only example of a very long distance transmission is one where the power is small, and is, therefore, in a certain sense, misleading. I have given you a formula by which you can calculate the most economical voltage for any distance ; and if you do this for many cases, taking, for instance, 500 H.P. as your unit of power, you will find that as the distance increases beyond five miles, the economical voltage begins to grow beyond the limit which might be considered practicable for one machine. It is quite impossible to lay down hard and fast rules. Under certain conditions, especially if you have to transmit cheap water-power, you may possibly reach a distance of 10 miles before getting to the limit of voltage ; but, whatever may be the special conditions of the problem, there is a limit of distance beyond which a single machine will not reach. "Very well, then," you might say, "if a single machine cannot be made to give the required pressure, let us put two or three machines in series." To correctly appreciate such a suggestion, let us first of all see what limits the voltage of a machine. Two things limit it ; the commutator and the general insulation. Practical dynamo makers will tell you in large machines they are quite prepared to put 1,000 volts on the usual Pacinotti commutator—if necessary, they will go to 2,000 volts, but with some misgiving ; and if you ask them to make a machine for 3,000 volts, they will, as likely as not, refuse. I do not refer to the Thomson-Houston or Brush machines, which have special commutators, but to large machines giving an even current and a high efficiency, such as we require in the transmission of power. We may thus conclude that 2,000, or, at the outside, 3,000 volts, is the limit of voltage to be obtained from a single commutator. But the general insulation of the machine must also stand this pressure, and where, as in dynamos and motors, the insulation consists of cotton, paper, fibre, varnish, and like materials, which are subjected not only to electrical, but also to mechanical strains, 3,000 volts is quite high enough for safe working. The commutator difficulty can, of course, be got over by putting several machines in series and insulating their frames from earth. The difficulty of general insulation can, however, not be met so easily. This you

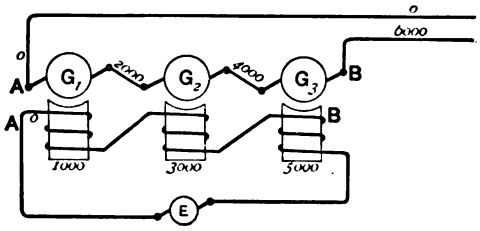

FIG. 7.

will see by referring to Fig. 7, which shows, diagramatically, three 2,000 volt machines placed in series. Shunt excitation at the high pressure of 2,000 volts is, of course, out of the question ; series excitation introduces complication and certain difficulties, especially at the motor station ; and separate excitation, although simple and easily worked, has the disadvantage of throwing great electrical strains upon the insulation between the exciting coils and the frames of the machines. Imagine, for instance, that there is a weak place at A, between the exciting coil and the frame of the first machine, then the strains between the exciting coil and the frame of the third machine at B, will be about 6,000 volts, even if all the machines are perfectly insulated from earth. With series self-exciting machines, the strain would, of course, be limited to 2,000 volts, but there still remains the difficulty that all the armatures would have to be mechanically connected by insulated couplings, and there would also be great danger in touching even the iron frame of any machine. You see the use of several machines in series is not such an easy matter as it may look at the first glance, and this method has, as far as I know, only been adopted in cases where the total voltage was under 2,000.

The net result of our investigation may be stated by saying that the electric transmission of power by continuous currents is economical and safe up to distances for which the most economical voltage does not exceed 2,000, or, at the outside, 3,000 volts, but that beyond these distances some other system must be applied. That this other system must also be electrical is evident, for we know perfectly well that distances beyond the reach of our present electric transmission systems are hopelessly beyond the reach of lines of shafting, flying ropes, air, or water. Now what is this new electrical system which shall enable us to carry power over ten or twenty, or perhaps a hundred miles ?

In attempting to answer this question I must perforce leave the safe ground of solid facts and engineering practice, and enter into the domain of speculation. Yet speculation based upon experimental results which in themselves are as reliable as were those experimental results which have led to the practical development of electric-power transmission as we know it now.

The starting point in the theory which I have now to bring before you is the well-known disc of Arago. If a copper disc be rapidly revolved under a compass needle, the latter is also set into rotation. I am able to show you this experiment, by the kindness of the Science and Art Department, who have lent me the apparatus you see before you. Between the copper disc and the compass needle is placed a sheet of glass so as to prevent air currents from affecting the needle. If I set the disc in motion you see that the magnet very soon follows. To make the motion of the latter better visible, coloured pieces of paper are attached to the poles. Now, the fact that the magnet revolves is evidently due to there acting upon it some mechanical force. The explanation is perfectly simple. The disc, in passing under the poles of the magnet, becomes the seat of a very complex system of electromotive forces, which produce an equally complex system of currents. Some of these currents cross the path of the lines of force emanating from the magnet, and thus mechanical forces are set up between the disc and the magnet, causing the latter to rotate. It is as though there existed between the disc and the magnet a kind of electro-magnetic friction by which the magnet is dragged after the disc. Since all motion is relative, it is perfectly clear that we might regard the magnet as revolving, and then the disc will be dragged after it. With the apparatus before you this experiment would not succeed, since the magnet is small and the disc is heavy ; but if we were to employ a very strong magnet, and revolve it rapidly enough, there would be no difficulty in setting the disc in rotation, and even obtaining power from it. I have said a moment ago that the system of currents set up in the disc is very complex, and you will easily see that only those currents which are more or less radial, and of these only their radial components, are instrumental in exerting mechanical force, whilst all the other currents represent simply so much waste power. To make an efficient machine we must, therefore, not employ a continuous disc, but a system of conductors, so arranged as to force the currents to flow as much as possible in a radial sense, and only in those places which are immediately under the influence of the magnetic field. Or, better still, we may abandon the disc shape of conductors altogether, and substitute an armature with a laminated iron core of the drum type, seen end on in Fig. 8, and use, instead of a straight magnet, a horse-shoe magnet, so shaped as to bring its poles,

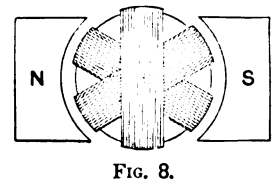

FIG. 8.

N S, to opposite sides of the drum, and wind the latter with a number of coils closed in themselves. If we now revolve the magnet, strong currents will be generated in each coil successively, and a very small torque will be exerted on the armature. The torque will, in fact, be comparable to that required to revolve an ordinary continuous current drum armature in a strong field, if we short circuit the brushes. Here, you see, we have, by applying a few very obvious improvements to the Arago disc, at once obtained a machine of very considerable power. Imagine both the magnet and the armature mounted on independent spindles (not shown in the diagram, but passing both at right angles through the centre of the figure), then it is perfectly clear that power given to the magnet spindle is transmitted, by electro-magnetic induction, to the armature ; and a large portion of it may, therefore, be obtained again from the armature spindle. Here we have, certainly, transmission of power, but not of the kind we require, since the distance of transmission is nothing. Now, what we want to do is to so alter our machine as to separate the two parts. We want the magnet in one place and the armature in another place, miles away, If, in this case, we succeed in transmitting rotation from the magnet to the armature, then we shall have solved the problem. This problem has been solved by an Italian electrician, Prof. Gallileo Ferraris, of Turin, who, early in 1888, communicated to the Turin Academy the results of his investigation on rotating magnetic fields produced by alternating currents. To clearly see the bearing which Ferraris's investigation has on our problem, let us inquire what it is we want at the motor station. We want there an armature, as shown in Fig. 8, and a magnetic field, the lines of which shall pass through the armature, and shall revolve round its centre. Whether the field is due to a real magnet, or is produced by any other means, is immaterial ; and it is the merit of Ferraris to have shown us how to produce such a revolving field without the use of a real magnet, but simply by the use of two distinct alternating currents passing through fixed coils.

As the subject is new, and will not be found in any of the numerous text-books dealing with electrical engineering, you will, per-

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haps, not think it out of place if I put it before you in rather an elementary manner, beginning with the simplest possible case, and passing gradually to the more complicated cases. Assume, then, a combination of apparatus, as shown in Fig. 9. Here you have, on the left, an annular iron core wound with two coils, which are connected in series, and to a pair of line wires going to a similar coil on the right, which may be at any distance. Into the circular space enclosed by the first coil we put a straight bar magnet, N S, which can revolve round the centre. As the poles sweep past the wire turns, an E.M.F. is induced, and a current is caused to flow, the direction of which changes twice in every revolution. We have here, in fact, an ordinary alternate current generator, with stationary armature and revolving field magnet. By suitably proportioning and placing the various parts of the apparatus, we can make the E.M.F. and the current curve of a true sine character; and, in order to simplify the treatment, I shall assume that in this, and in the cases which follow, the design is such that all the E.M.F. and current waves follow the sine law. The alternating current, in passing through the coils on the right, magnetise the iron core, so

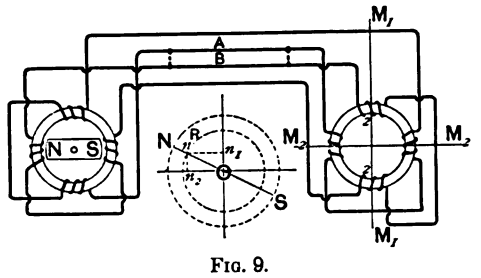

Fig. 9.

as to develop north and south polarity in the line M_1 M_1. The effect is the same as if we placed into the ring a vertical magnet which is collapsible, the two poles shrinking into a point at the moment that the current strength is zero, and coming apart vertically as the current increases. We must imagine this magnet alternately shrinking into nothing and growing larger and stronger; also reversing its polarity each time that it passes through its zero condition. In the apparatus shown by Fig. 9, therefore, rotation of a real magnet on the left produces merely an oscillating magnetic field on the right. As you know, a magnetic field may be represented graphically, in direction and magnitude, by a straight line; and, in this particular case, the line so representing the oscillating field is the projection of the radius, O n, on the vertical M_1 M_1, if the length of the radius, O n, represents the strength of the field at maximum current. At the moment to which the diagram refers, our collapsible magnet will, therefore, have grown to the strength represented by the length, s_1 n_1; and, if there were no lag, the real revolving magnet would, at that moment, occupy the position, S N. As there must be some loss in the transmission, I have shown N at a larger radius than n. If there is lag, then n and N will not lie on the same radius, but n will occupy, say, the position n', and the strength of the oscillating field

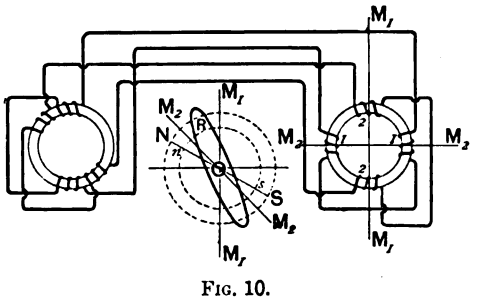

Fig. 10.

will be n_1', s_1'. The practical effect of lag is this, that the revolving magnet will have passed the vertical position shown in the diagram by the time the current has reached its maximum; and I can, therefore, eliminate the lag from the graphic diagram, by assuming that the revolving magnet has been shifted back through an angle equal to the angle of lag in this diagram, but left in its true position in the diagram representing the apparatus itself. In Fig. 9 the coils on the ring on the right hand are placed on the horizontal diameter. If, as in Fig. 10, I place them on the vertical diameter, the resulting oscillating field will be horizontal, namely, on the line, m_1 m_2; and the projection of n on the vertical must be taken over to the horizontal, as shown by the dotted quarter circle. Let us now suppose that we have both horizontal and vertical coils on the ring, as shown in this figure, then the combined effect of these coils willl be to produce an oscillating field on the line, R R, the strength of the field being, as you will easily understand, about 40 per cent. greater than in either of the former cases; but still the field is not a revolving one. I can show you the production of an oscillating field, as here explained, by means of a mechanical model.

Up to the present, then, we have not advanced in the solution of our problem. We have produced at the distant point an oscillating field; but what we want there is a revolving field; and to get this we must duplicate the apparatus shown in Fig. 9, by putting horizontal coils on the generator and vertical coils on the motor ring, in addition to the coils already there. This arrangement is shown in Fig. 11. Now, the field produced by the coils, 1 1, is given by the projection of O n on the vertical; and that produced by the coils 2 2 is given by the projection of O n on the horizontal. The resultant of these two fields is therefore O n, the point n revolving round O as a centre on the circle R. The effect of revolving a real magnet within the generator ring is, then, to produce a revolving magnetic field of the strength O n within the motor ring, a kind of revolving phantom magnet which, for our purpose, is quite as suitable as a real magnet. I can also show you this effect by means of the mechanical model.

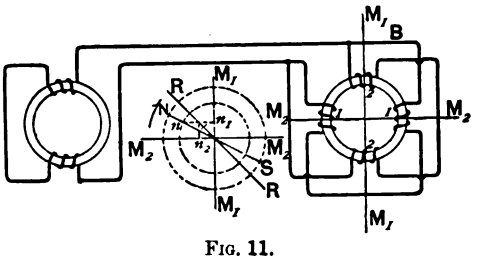

Fig. 11.

You observe that in Diagram 11 four wires are shown, connecting the generating and receiving machines. Now, as the absolute potential of any of these wires may be chosen arbitrarily, there is obviously nothing against choosing it at such a value as will make it coincide with the absolute potential of another wire not belonging to the same circuit. We might thus, for instance, equalise the potential between the wires A and B by connecting them at either terminus, as shown by dotted lines, and not disturb in any way the satisfactory working of the machines. Or, better still, we may omit one of the wires altogether, and use the other as a common wire for both circuits, and thus reduce the total number of wires to three. The common wire must, however, have about 40 per cent. more carrying capacity, since the algebraical sum of the two currents is 1·4 times the strength of each current taken singly. Here you have, then, the theoretical solution of the problem of how to transmit power by alternating currents, as indicated by Ferraris, but the first to attack this problem practically was Mr. Tesla, an American electrician, and such motors are, therefore, also known under the name of Tesla motors, though the name "Ferraris motors" seems to me to be more appropriate, as distinguishing this motor from the two-wire Tesla motors, about which I shall say something presently. To carry out a power transmission by means of such a system, we must have at the generating station an alternator, the armature of which is wound with two circuits giving currents with a quarter period phase difference, three-line wires, and a motor having a laminated field magnet, which is excited by coils placed alternately in the two circuits so as to produce a

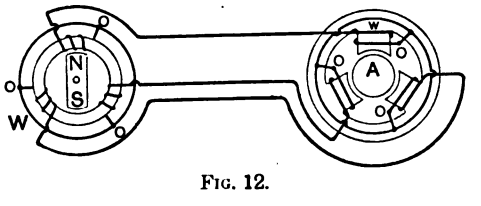

Fig. 12.

revolving field. The armature of this motor must have an iron core, surrounded with coils closed in themselves.

The necessity of using three-line wires is, to a certain extent, a disadvantage of this system, and several engineers, Mr. Tesla foremost amongst them, have tried to improve the system in such a way that two-line wires only should suffice. The methods suggested have this in common, that all aim at producing a difference in phase between the currents passing through the motor, without the use of a second set of coils on the generator. If we insert, for instance, a large inductionless resistance into the branch B in Fig. 10, and a coil having very little resistance, but great self-induction, into the branch A, the current in the coils 1 1 will lag by a small amount behind the E.M.F. impulses of the generator, whilst the current in the coils 2 2 will lag behind these impulses by a larger amount. The phase difference between the two currents can, of course, not amount to 90deg., which angle is required for producing the best

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effect, but some difference of phase can certainly be produced in this way. The arrangement will, in fact, be equivalent to that shown in Fig. 12, where the distance between the two sets of coils on the generator is less than 90deg.

An easy geometrical construction, which I need not explain at length, shows that in this case the path of either pole of what I have before called the revolving phantom magnet is an ellipse, but that it can be made to be circular by a dis-symmetrical arrangement of the coils on the motor, though in this case the diameter of the circle is much reduced. In either case the value of the machine as a power-producing appliance is also much reduced, whilst at the same time the efficiency must be low, owing to the waste of power in the resistance coil. I can also show you the action of this two-wire motor by means of the mechanical model.

(To be continued.)

VARIATIONS OF CONDUCTIVITY UNDER ELECTRICAL INFLUENCE.*

BY E. BRANLY.

In a preceding article I showed that certain substances undergo an increase in conductivity under various electrical influences, and that these substances are numerous. The increase in conductivity varies with the energy of the exciting source. If the electric influence is due to the passage of a continuous current, the increase in conductivity is greater the greater the electromotive force of the battery employed. There is, however, no proportionality, the increased conductivity growing more rapidly than the number of cells, and tending quickly to a maximum. If the electric action consists in the passage of discharge currents in metallic rods, as in arrangment A (Fig. 1), the conductivity increases with the length of spark at S, and it also increases when the rods are brought nearer the sensitive substance. Successive sparks are additive in their effects, although, if the action of the first one has been very powerful, the resistance is sometimes almost immediately reduced to a minimum.

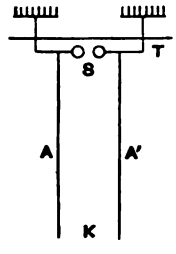

FIG. 1.

Restoration of Original Resistance.—The conductivity caused by the various electrical influences lasts sometimes for a long period (24 hours or more), but it is always possible to make it rapidly disappear, particularly by a shock.

The majority of substances tested showed an increase of resistance on being shaken previous to being submitted to any special electrical influence, but after having been influenced the effect of shock is much more marked. The phenomenon is best seen with the metallic filings, but it can also be observed with metalised ebonite sheets with mixtures of liquid insulators and metallic powders, mixtures of metallic filings and insulating substances (compressed or not compressed), and finally with solid bodies.

I observed the return to original resistance in the following manner :—The sensitive substance was placed at K (Fig. 1), and formed part of a circuit which included a Daniell cell and galvanometer. At first no current passes. Sparks are then caused at S, and the needle of the galvanometer is permanently deflected. On smartly tapping the table supporting the ebonite cap in which the sensitive substance is contained, the original condition is completely restored. When the electric action has been of a powerful character, violent blows are necessary. I employed for the purpose of these shocks a hammer fixed on the table, the blows of which could be regulated.

With some substances, when feebly electrified, the return seemed to be spontaneous, although it was slower than the return of the galvanometer needle to equilibrium. This restoration of the original resistance is attributable to surrounding trepidations, as it was only necessary to walk about the room at a distance of a few metres, or to shake a distant wall. This spontaneous return to original resistance after weak electrical action was visible with a mixture of equal parts of fine selenium and tellurium powders. The restoration of resistance by shock was not observable so long as the electrical influence was at work.

After having been submitted to powerful electric action, shock does not seem to entirely restore substances to their original state, in fact, the substances generally show greater sensitiveness to electric action. Thus, a mixture of colza oil and antimony powder being exposed to the influence of arrangement A, a spark of 5mm. was at first necessary to break down the resistance, but after the conductivity had been made to disappear by means of blows, a spark of only 1mm. was sufficient to again render the substance conducting. Finely powdered aluminium has an extremely high resistance. A vertical column of powdered aluminium 5mm. long of 4 sq. cms. cross-section, submitted to considerable pressure, completely stopped the current from a Daniell cell. The influence of arrangement A produced no effect, but, by direct contact with a Leyden jar, the resistance was reduced to 50 ohms. The effect of shock was then tried, and after this the sparks produced by arrangement A were able to reduce the resistance.

The following experiment is also of the same kind. Aluminium filings placed in a parallelipidic trough completely stopped the current from a Daniell cell, and the resistance offered to a single cell remained infinite after the trough had been placed in the circuit of 25 sulphate of mercury cells for 10 seconds. The aluminium was next placed in circuit with a battery of 75 cells ; a single Daniell cell was then able to send a current through the substance. The original resistance was restored by shock, but not the original condition of things, since a single cell was able to send a current after the aluminium had been circuited for 10 seconds with a battery of only 25 cells. I may add that if the restoration of resistance was brought about by a *violent* shock, it was necessary to place the aluminium in circuit with 75 cells for one minute before the resistance was again broken down.

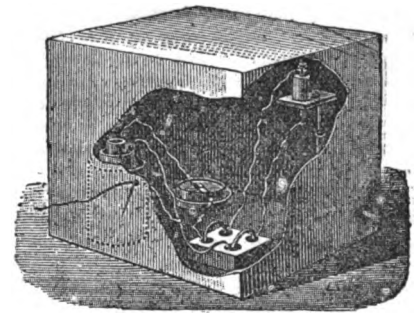

FIG. 2.

It must be observed that electrical influence is not always necessary to restore conductivity after an apparent return to the original resistance, repeated feeble blows being sometimes successful in bringing this about. Both in the case of slow return by time and sudden return by shock, the original value of the resistance is often increased. Rods of Carré carbon, 1 metre long and 1mm. in diameter, were particularly noticeable for this phenomenon.

Return to Original Resistance by Temperature Elevation.—A plate of coppered ebonite rendered conducting by electricity, and placed close to a gas jet, quickly regained its original resistance. A solid rod of resin and aluminium, or of sulphur and aluminium, rendered conducting by connection to the poles of a small battery will regain its original resistance by shock, but if the conducting state has been caused by powerful means, such, for instance, as direct contact with a Leyden jar, shock no longer has any effect, at least such a shock as the fragile nature of the material can stand. A slight rise of temperature, however, has the desired result. By suitably regulating the electric action it is possible to get a substance into such a condition that the warmth of the fingers suffices to annul conductivity.

Influence of Surroundings.—Electric action gives rise to no alteration of resistance when the substance is entirely within a closed metal box. The sensitive substance, in circuit with a Daniell cell and a galvanometer, is placed inside a brass box (Fig. 2). The absence of current is ascertained, the circuit broken, and the box closed. A Wimshurst machine is then worked a little way off, and will be found to have had no effect. The same result will be obtained if the circuit is kept closed during the time the Wimshurst

* Abstract from *La Lumière Electrique*. For abstract of the first portion of this article see *The Electrician*, June 26, p. 220.

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machine is in operation. If a wire connected at some point to the circuit is passed out through a hole in the box to a distance of 20 to 50 cms., the influence of the Wimshurst machine makes itself felt. On tapping the lid to restore resistance the galvanometer needle remains deflected so long as the sparks continue to pass. If, however, the wires are pushed in so that they only project a few millimetres, the sparks still passing, a few taps suffice to bring back the needle to zero. On touching the end of the wire with the fingers or a piece of metal conductivity is immediately restored. The movements of the galvanometer needle were rendered visible in these experiments by looking through a piece of wide mesh wire gauze with a telescope. The respective position of the things was also reversed ; that is to say, a Ruhmkorff coil and a periodically discharged Leyden jar were placed inside, and the sensitive substance outside, the box, with the same results.

In some later experiments with a larger metallic case, and with the Daniell cell, sensitive substance, delicate galvanometer, and Wheatstone Bridge placed inside, I found that a double casing was necessary in order to absolutely suppress all effects. A glass covering afforded no protection.

Considerations on the Mechanism of the Effects Produced —What conclusions are we to draw from the experiments described ? The substances employed in these investigations were not conductors, since the metallic particles composing them were separated from each other in the midst of an insulating medium. It was not surprising that currents of high potential, and especially currents induced by discharges, should spark across the insulating intervals. But as the conductivity *persisted* afterwards, even for the weakest thermo-electric currents, there is some ground for supposing that the insulating medium is transformed by the passage of the current, and that certain actions, such as shock and rise of temperature, bring about a modification of this new state of the insulating body. Actual movement of the metallic particles cannot be imagined in experiments where the particles in a layer a few millimetres thick, were fixed in an invariable relative position by extreme pressures, reaching at times to more than 100 kilogrammes per sq. cm. (1,420lb. to the square inch). Moreover, in the case of solid mixtures, in which the same variations of resistance were produced, displacement seems out of the question. To explain the persistence of the conductivity after the cessation of the electrical influence, are we to suppose in the case of metallic filings a partial volatilisation of the particles creating a conducting medium between the grains of metal? In the case of mixtures of metallic powders and insulating substances agglomerated by fusion, are we to suppose that the thin insulating layers are pierced by the passage of very small sparks, and that the holes left behind are coated with conducting material ? If this explication is admissible for induced currents, it must hold good for continuous currents. If so, we must conclude that these mechanical actions may be produced by batteries of only 10 to 20 volts electromotive force, and which only cause an insignificant current to pass. The following experiment is worth quoting in this connection :—

A circuit was formed by a Daniell cell, a sensitive galvanometer, and some aluminium filings in an ebonite cup. The galvanometer needle remained at zero. The filings were cut out of this circuit, and switched for one minute into circuit with a battery of 43 sulphate of mercury cells. On being replaced in the first circuit, the filings exhibited high conductivity. The result was the same when 10 or 20 cells were employed, or when the current was diminished by interposing in the circuit a column of distilled water, 40cm. long and 20mm. in diameter. The cells used (platinum, sulphate of mercury, sulphate of zinc, zinc) had a high internal resistance. Thus, 43 cells (60 volts), when short circuited, only gave a current of 5 milliamperes. The same battery, with the column of distilled water in circuit only, caused a deflection of 100mm. on a scale one metre off, with an astatic galvanometer wound with 50,000 turns. We can, therefore, see how infinitesimally small the initial current must have been when the filings were added to the circuit. The battery acted, therefore, essentially by virtue of its electromotive force.

If mechanical displacement of particles or transportation of conducting bodies seem inadmissable, it is probable that there is a modification of the insulator itself, the modification persisting for some time by virtue of a sort of "coercive force." An electric current of high potential, which would be completely stopped by a thick insulating sheet, may be supposed to gradually traverse the very thin dielectric layers between the conducting particles, the passage being effected very rapidly if the electric pressure is great, and more slowly if the pressure is less.

Increase of Resistance.—An increase of resistance was observed in these investigations less often than a diminution ; nevertheless, a number of frequently repeated experiments enable me to say that increase of resistance is not exceptional, and that the conditions under which it takes place are well defined. Short columns of antimony or aluminium powder when subjected to a pressure of about 1 kilogramme per sq. cm. (14·2lb. per square inch), and offering but a low resistance, exhibited an increase of resistance under the influence of a powerful electrification. Peroxide of lead, a fairly good conductor, always exhibited an increase ; so also did some kinds of platinised glass, while others showed alternate effects. For instance, a sheet of platinised glass, which offered a resistance of 700 ohms, became highly conducting after 150 sulphate of mercury cells had been applied to it for 10 seconds. This condition of conductivity was annulled by contact with a charged Leyden jar, and reappeared after again applying 150 cells for 10 seconds, and so on. Similar effects were obtained with a thin layer of a mixture of selenium and tellurium poured, when fused, into a groove in a sheet of mica placed between two copper plates. These alternations were always observed several times in succession, and at intervals of several days.

These augmentations and alternations are in no way incompatible with the hypothesis of a physical modification of the insulator by electrical influence.

ACCUMULATOR TRACTION.

The following figures, extracted from the recent report of the Directors of the Birmingham Central Tramways Company, are perhaps the most reliable that have hitherto been published on the important question of the actual cost of accumulator traction. These figures are rendered all the more valuable owing to the detailed manner in which they are set out, and the fact that the same company also employs horse, steam, and cable cars on an extensive scale.

Miles Run and Passengers Carried.

System.	Miles run.	Passengers carried.	Passengers carried per car mile.
Steam	1,184,401	14,242,827	12·02
Horse. Tramways	131,528	1,114,388	5·3
Horse. Omnibuses	506,196	2 638,028	
Cable	522.876	5,241.362	10·02
†Electric	138,396	1,144.718	8·27
Total	2,483,397	24,381,323	

† The showing of the electric cars is, therefore on 5·6 per cent. of the total number of car miles run, and on 4·7 per cent. of the total number of passengers carried.

Cost of Traction, Gross Receipts, and Net Profit per Car-Mile Run.

Steam.		Horse.		Cable.		Electric.	
Gross Receipts	15·67	Gross Receipts	11·02	Gross Receipts	12·83	Gross Receipts	15·15
Cost of Traction—		Cost of Traction—		Cost of Traction—		Cost of Traction—	
Engines	6·38	Horses	7·33	Cable haulage	2·41	Electric haulage	5·15
Car repairs	·33	Vehicle repairs	·54	Cables and machinery	·95	Machinery	·29
Traffic expenses	1·68	Traffic expenses	1·26	Car repairs	·83	Car repairs	1·93
Permanent way and buildings	1·55	Permanent way and buildings	·14	Traffic expenses	1·30	Traffic expenses	1·34
General charges	1·05	General charges	·52	Permanent way and buildings	·13	Permanent way and buildings	·14
				General charges	·71	General charges	1·05
Total	10·99	Total	9·79	Total	6·33	Total	9·90
Net Profit	4·68	Net Profit	1·23	Net Profit	6·50	Net Profit	5·25

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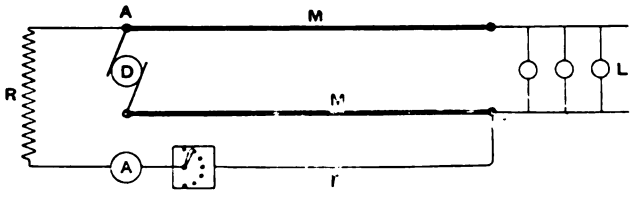
THE REGULATION OF ELECTRICAL DISTRIBUTION FROM CENTRAL STATIONS.*

BY J. LAFFARGUE.

It is of the highest importance, as every one knows, to ensure constant potential or constant current, as the case may be, in electrical distribution from central stations, and I propose to examine in the same way as did Herr Imhoff, in a recent issue of the *Elektrotechnische Zeitschrift*, the principal methods hitherto adopted in constant potential systems.

Practice has shown that, in order to ensure good regulation, it is necessary to keep the difference of potential at the station constant to within one or two volts. In small installations, where the demand is all or nothing, there is no difficulty. But in the case of central stations considerations such as first cost and depreciation often result in the employment of mains in which as much as 15 volts are lost with maximum load. I will not detail the various systems of distribution which have been devised to secure constant potential, but will suppose that regulation at the dynamo terminals is sufficient, and to avoid complication I will take a feeder installation. In this system the problem is to maintain a constant difference of potential at the points of junction of the feeders with the supply circuits. Let us now examine the different methods adopted up to the present day.

1. *Regulation by Altering the Resistance of the Exciting Circuit.*—In the case of a single machine one can regulate the difference of potential by introducing or cutting out resistance in the exciting circuit. This regulation is carried out according to the indications of a voltmeter or pilot-lamp connected to the extremities of the system. In the case of distribution by feeders this method keeps the difference of potential at the station constant whatever may be



the loss in the feeders, which have, however, their own regulating appliances. When the machines are connected in parallel the regulation of the exciting circuit allows the load to be divided between them all, and the potential to be kept constant at the same time.

2. *Regulation by Introducing Resistance into the Main Circuit.*—If E be the difference of potential at the terminals of the central station dynamo, R the resistance of the line, C the current, we have for e the difference of potential at the end of the line,

$$e = E - CR.$$

As e varies according to C, it is necessary to vary R in the inverse direction in order to keep C R constant. This method has been employed by Menges, Graner, Lahmeyer, Schuckert, and others.

3. *Regulation by Accumulators.*—Regulation by means of accumulators can be carried out in several ways. They can be put in series in the main circuit and their number varied as required. The accumulators in this case play the part of ordinary resistances. We can also charge accumulators in series and discharge them in parallel, varying the number in each group. Examples of this method are the central stations in the Rue de Bondy and in the Rue des Filles Dieu in Paris, and the Chelsea Electricity Supply Company station in London.

4. *Regulation by an Auxiliary Dynamo.*—This method, advocated by Prof. Perry and put into practice by Herr Lahmeyer, consists in introducing an auxiliary dynamo into the main circuit. At a constant speed this dynamo produces an additional electromotive force proportional to the strength of the main current, and, therefore, proportional to the fall of potential on the circuit, so that the difference of potential remains constant. This method of working has the advantage over the others of not uselessly expending energy.

5. *Regulation at the end of the line.*—Herr Imhoff points out a new method of regulation, which consists in completing the exciting circuit by a wire connected to the far end of the leads. From the dynamo D (see Fig.) run the two leads. The exciting circuit starts from the pole A and includes the resistance R, an ammeter, and a variable resistance. Let M M be the resistances of the mains, r that of the return wire; L the resistance of the lamps, &c., C the strength of the main current, c that in the exciting circuit; E the difference of potential at the terminals of the dynamo, and e that at the extremity of the line. We then have

$$C = \frac{E}{2M+L} \text{ and } c = \frac{E}{R+r+M}$$

when the variable resistance = 0.

From this we get

$$\frac{c}{C} = \frac{\frac{E}{R+r+M}}{\frac{E}{2M+L}} = \frac{2M+L}{R+r+M}$$

$$c = C \times \frac{2M+L}{R+r+M};$$

but $$L = e/C \quad \ldots\ldots\ldots (1).$$

whence we have $$(R+r+M)c = C(2M+e/C),$$

whence $$e = (R+r+M)c - 2CM \quad \ldots\ldots (2).$$

Now it is e which ought to remain constant.

From (2) we have

$$e = c(M+R) + cr - 2CM;$$

now $$c(M+R) = \text{a constant} = K,$$

$$\therefore \quad e = K + cr - 2CM.$$

Now, for e to remain constant, $cr - 2CM$ must remain constant, which obtains when

$$cr = 2CM;$$

whence $$r = 2CM/c \quad \ldots\ldots\ldots (3).$$

The condition imposed by equation (3) is the following:—To keep a constant difference of potential at the distant end of the line, the fall of potential along the return wire must equal the total fall. To fulfil this condition, it is only necessary to vary r within certain limits. To effect this, a variable resistance is inserted in the exciting circuit.

This method, which it is easy to realise in practice, does not require more expensive apparatus than other methods. On the other hand, it permits us to realise the economy of a return wire. I think it worth while to call attention to this method on account of its convenience and practical facility.

* From *L'Electricien*.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *August* 8, 1891.

Fire at a Central Station.—One of the most disastrous fires that has taken place in an electrical establishment for some time occurred on Monday evening last, and resulted in the total destruction of the plant of the Richmond Light, Heat, and Power Company, at St. George, Staten Island. The flames were first noticed under the eaves of the boiler house about 8:30 in the evening, and an immediate attempt was made to suppress the fire. The Company had several hose lines attached to its fire-plugs, and these were at once brought into use, but, to the consternation of everybody, there was no water. The Staten Island Water-Supply Company had not pressure enough in its pipes to force the water through the hundred feet of hose, much less to carry it on to the flames. Before the fire-engines could be brought to the scene and into action the flames had made such headway that little could be done; gradually they passed from the boiler-room to the dynamo-room, and in spite of all efforts nothing could be done to save the plant, which was completely destroyed. The buildings burned were two, the boiler-house and the adjoining building, containing the dynamos. The former contained two 300, one 100, and three 80 H.P. boilers. The engines were one 700 H.P. Corliss, and two 80 H.P. smallhigh-speed engines. Eight dynamos of Westinghouse, Fort Wayne, American, Thomson-Houston, and Edison makes were burned. The total loss amounts to $75,000, about $50,000 of which was covered by insurance. Efforts were at once made to resume the lighting service with temporary apparatus. The Fort Wayne Electric Company offered to furnish 10 or 12 dynamos within 48 hours, and thus the electrical end of the new equipment was looked out for. Engine-power, however, was not quite so easily furnished, although several manufacturing establishments near have spare steam, which will probably be utilised. It is expected that light will be turned on again by Saturday night. The

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cause of the fire is as yet unknown; it is supposed to have been due to defective smoke flues. Despite the unfriendly remarks of insurance companies, electrical plants have proved to be, on the whole, very fair risks. There have been, aside from the present, but two plants of any magnitude destroyed within the present year; both of these were electric railway installations, one at Pittsburgh, Pa., and the other at Asbury Park, N.J. In neither case was the fire electrical in its origin.

The New York Rapid Transit Commission.—Some ugly rumours are going the rounds regarding the doings of the Rapid Transit Commission. When it first began its prolonged, and so far fruitless, lucubrations, plans from various engineers were called for, and a large number responded, elaborating more or less perfect systems for underground and overhead structures suited to the needs of the case. Many of the engineers who furnished these designs spent a large amount of time and money in getting up drawings and specifications of a very complete character. It now transpires that the engineers of the Commission are working up plans of their own, which will be foisted upon the public in due season. They claim to have secured the services of several noted engineers for consultation, but although these prove to be gentlemen of repute in their profession, they are far from being specialists in underground construction, one of them being a well-known bridge engineer, and another making a speciality of buildings. It looks very much as if the engineers of the Commission saw an excellent opportunity to make a reputation by the use of other people's brains, and were preparing to seize this opportunity quite irrespective of the rights of these others. It remains to be seen how far they will draw upon the various plans suggested, and what credit, if any, they will give to the authors of the various valuable suggestions that have been thrown out. Of course, it is necessary, as I have remarked before, for the Rapid Transit engineers to make a show of earning their salaries, but the public will not be very well pleased if they take this particular means of doing it.

Storage Battery Traction.—It is reported that storage battery cars will soon be running on the Fourth-avenue line again, and this is connected with a rumour of an approaching consolidation between the United States Electric Traction Company and the Julien Company, now sole licensee under the Brush patent, which has been recently sustained. Meanwhile other inventors in storage battery work do not seem to be appalled by the decision in favour of Brush, but are going on in various lines of work. Mr. C. P. Elieson, well known to you from his connection with storage battery traction in London, is now making some preparations to enter upon practical work here. At another time I may be able to give full details of what he is doing. Of the Waddell-Entz system that was lately described in the *Electrical World*, nothing more is heard. One or two more successful demonstrations have been made, but nothing commercial as yet.

TRADE NOTES AND NOTICES.

NOW READY.—"THE ELECTRICIAN" PRIMERS (38 in all. Vol. I., 20; Vol. II., 18), in two volumes. Price per volume 2s. paper covers, 2s. 6d. cloth; post free, 2s. 2d. and 2s. 9d. respectively. Single copies, 3d.; post free, 3½d. Prospectus on application to the Publisher.

COMPETITION.—The New Promenade Pier and Torquay Ferry Company offer a prize of £25 for the best size, design, and arrangement for new steam or electric launches for the passenger and parcels traffic between Paignton Promenade Pier and Torquay. The prize is to be awarded at the sole discretion of the subscriber, and all designs submitted to be his property and to be used as he may please. Further particulars are given in our advertisement columns, and full information and conditions can be obtained on application to the subscriber, Mr. Wm. Robertson, Managing Director of the Company, Paignton, South Devon. All designs have to be in on or before Saturday, September 5th next.

PLANT FOR SALE.—Our advertisement columns contain particulars of a complete private electric lighting plant for sale, in consequence of owner obtaining current from Central Supply Station.

VACANT APPOINTMENTS.—The Electricity Committee of the Vestry of St. Pancras invite applications for the following appointments:—Chief clerk of the electricity department, salary £150 per annum; resident engineer, central station at Regent's Park, £4 per week; engine driver, £3 per week; electrician for dynamos and switchboards, £3 per week; stoker, 35s.; stoker, 25s. per week; inspector of private works, £2. 10s. per week. Applications are to be made in writing on forms to be had on application at the Vestry Hall, and are to be sent with testimonials not later than Wednesday, the 26th inst. Further particulars are given in our advertisement columns.

——— The Urban Sanitary Authority of Bath propose to appoint an electric inspector, under the terms of the Bath Electric Lighting Licence of 1890. The licence and a plan of the compulsory and permissive electric area may be inspected at the office of Mr. F. H. Moger, clerk, 3, Wood-street, Bath. Applications for the appointment, stating remuneration required, with testimonials as to qualification, to be sent addressed to the clerk, on or before Friday, the 28th inst. Further particulars will be found in our advertisement pages.

THE KEYS' ELECTRIC COMPANY.—We have received from this Company a very exhaustive catalogue, in 35 divisions, of general electrical plant and apparatus. In this handy form the catalogue will be found very useful to the trade. Each division is fully illustrated, and includes a description and price list of the apparatus to which the section is devoted. The various parts refer to the following manufactures:—Motors, regulators, arc lamps, arc lamp suspension gear, carbons, measuring instruments, physical, electrical, and magnetic instruments, incandescent lamps, lampholders, switch-boards, main switches, safety switches and fuses, cut-outs, insulators, wires and cables, dynamos, dynamo fittings, accumulator plants, and electric launches. One division is specially devoted to theatre lighting and specialities for use therein.

THE ELECTRIC LIGHT AT EXETER.—The Exeter Literary Society have just had completed an installation of the electric light in their new lecture hall and adjacent building. The main hall is well lighted by 33 Edison-Swan lamps of 32 and 16 c.p., the lamps being enclosed in acid-ground shades. The lights on the stage are connected to wall-sockets with a sufficient length of flexible cord to allow of their being utilised as foot-lights or battens, the total number of lamps installed being about 90. The installation was carried out and current supplied by the Exeter Electric Light Company, which is now running an equivalent of nearly 3,000 8 c.p. lamps and 26 arcs.

THE TELEPHONE AT RIFLE MEETINGS.—At the meeting, on August 14th and 15th, at Altcar, Liverpool, of the County Rifle Association six sets of telephone instruments were erected by the National Telephone Company (Liverpool district) between the firing points and the targets on the 200, 500, and 600 yards ranges. They were much used for communicating with the markers.

MESSRS. DRAKE AND GORHAM.—The Governors of Felstead School have decided to introduce the electric light throughout the whole of the buildings under their control, and have placed the contract with Messrs. Drake and Gorham. The installation will consist of about 460 lamps, which will be supplied by two separate engines.

MESSRS. ARMFIELD AND CO.—From this firm we are in receipt of illustrated particulars of their "British Empire" turbine, for which a number of advantages are claimed. The makers state that it is easy to stop and start, and is especially suitable for variable streams. Illustrations accompany the particulars showing a double turbine with double horizontal gates, and a single turbine with a single horizontal gate, as well as turbines with single vertical gates.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

July 27, 1891.

12,703. T. HAWKINS. London. Improvements in or connected with switch-boards for electrical purposes.

12,702. A. T. SNELL. London. Improvements in electric coal-cutting machine.

12,726. W. P. THOMPSON. Liverpool. Improvements in the construction armatures for certain kinds of electrical machines. (W. Lahmeyer and Co., Germany.)

12,731. C. S. F. MELLOR. London. An automatic locomotive or electrical engine.

12,727. W. P. THOMPSON. Liverpool. Improvements in the method or means of regulating motor-dynamos or continuous current transformers. (W. Lahmeyer and Co., Germany.)

July 28, 1891.

12,774. O. FRANCIS. London. A new electro dia-magnetic self-rotating dynamo.

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12,792. A. W. KING. London. An improved bolt socket electric light switch.
12,799. M. FEILBOGEN. London. Improvements in and relating to system of electric distribution.
12,824. G. ZANNI. London. An improvement connected with electric lighting apparatus.
12,828. H. H. LAKE. London. Improvements relating to electric motors chiefly designed for railway and other vehicles, and to electric generators. (The Thomson-Houston International Electric Company, United States.)
12,831. W. RUSSELL. London. Improved curative electric belt.
12,334. W. W. HORN. London. An improved electric apparatus for treating deafness. (G. F. Webb, United States.)

July 29, 1891.

12,859. G. WILSON. Bristol. A method of and means for combining at will telephonic communication with ordinary methods of electrical signalling in or about coal and other mines and works and other places.
12,898. T. PARKER. London. Improvements in means to be employed in the electrical deposition of copper.

July 30, 1891.

12,904. R. A. SCOTT. London. Improvements in holders for incandescent electric lamps.
12,934. A. R. BENNETT. London. An electrical parcel exchange system.
12,946. J. A. TIMMIS and W. H. WALEUN. Improvements in the electro-deposition of platinium.
12,960. W. M. MORDEY. London. Improvements in electric transformers.

July, 31, 1891.

12,982. F. G. M. WETHERFIELD. London. An electric automatic time check. (C. K. Jardine, Demerara.)
12,985. R. B. ANNESLEY, J. H. EVANS, and E. BLAKEY. London. Improvements in means or apparatus for use in automatic electric railway signalling.
13,015. G. H. GRAHAM and T. GANNANE. London. Improved electric insulator.

August 1, 1891.

13,087. A. M. ELTON. London. Improvements in electric apparatus for maintaining a uniform, or approximately uniform, temperature within a chamber or vessel, specially applicable to incubators.
13,096. J. A. MCMULLEN. London. Improvements relating to conduits, applicable for combined use as casings for electrical conductors, and for gas supply, or for either use separately.
13,114. T. PARKER. London. Improvements in or connected with electric furnaces.
13,124. H. HOWARD. London. Improvements in heating and welding by electricity.
13,125. H. HOWARD. London. Improvements in carbon holders and screens, suitable for electric welding.

August 4.

13,163. W. BLENHEIM. Egham. Improvements in carbon transmitters for telephonic purposes.
13,167. T. D. WILLIAMS. Blackburn. Showing when the bell of a telephone has been ringing, or "a sight indicator for telephones."
13,171. J. CRIGGAL, J. BERKLEY, and C. F. WILLIAMSON. London. An improved socket for incandescent electric lamps.
13,200. G. C. DYMOND. Liverpool. Improvements in fence posts, telegraph posts, or the like. (F. P. Rosback and H. F. Band, United States).
13,208. E. CASPER. London. Improvements in the manufacture of wire, bars, bands, and sheets of copper by electrolysis, and in apparatus therefor. (E. Piarengo, Italy).
13,250. W. H. WHEATLEY. London. Improvements in electrical switches and safety fuses. (A. Ashfalck, Germany).
13,252. C. FÉRY and E. DUCRETET. London. Improvements in electrical contact making and breaking devices.
13,268. W. W. HORN. London. Improvements in electrical fire alarms. (B. W. Leonard and J. C. Nichols, United States).
13,269. E. A. GIMINGHAM. London. An improvement in connecting the conductors of electrical glow lamps.

August 6, 1891.

13,274. P. E. SINGER. London. Improvements in electric meters.
13,315. J. Y. JOHNSON. London. Improvements in arc lamps. (C. Bellens, France).
13,331. M. G. KELLOGG. London. Improvements in telephony, and apparatus therefor.

August 7, 1891.

13,335. L. H. CLINE. Hull. Electric tell-tale for the control of masthead, stern, and side lights on steamers.
13,362. G. FORBES. London. Improvements in dynamo-electric machines.
13,366. J. D. MASSEY. London. Improved telephone transmitter.
13,367. T. B. SLOPER. London. Improvements in electric telephone switches and systems.
13,371. H. H. LEIGH. London. Improved electro-manual devices for the actuation of gravity signal arms, points, and the like. (A. Hillairet and A. Hugnet, France.)
13,372. A. H. BYNG. London. An improved electric or galvanic brush.
13,384. G. FORBES. London. Improvements in electrical contacts.
13,387. J. H. CAZAL. London. Improvements in dynamo-electric generators.

August 8, 1891.

13,437. A. J. HOWES. London. An improved method of, and means for, electrical communication between parts of railway trains.
13,446. W. J. S. BARBER-STARKEY. London. An improvement in secondary voltaic batteries.

August 10, 1891.

13,465. W. GADD and O'DREY. Manchester. Improvements in electrical automatic stopping apparatus for weft pile cutting machines.
13,492. F. E. ELMORE. London. A method and apparatus for electrical propulsion of vehicles.
13,503. M. VON DOLIVO-DOBROWOLSKY and the COMPANY ALLGEMEINE ELEKTRICITÄTS GESELLSCHAFT. London. Improvements in electric machines and apparatuses for differential phase alternating currents.

August 11, 1891.

13,528. A. DOUGLASS. London. Improved electric time-registering apparatus for use in cabs and the like.
13,529. J. A. BRIGGS. London. Improvements in methods and apparatus for obtaining and utilising electric light.
13,553. W. MITCHELL. London. Improvements in electrically-heated ovens.
13,554. W. MITCHELL. London. Improvements in electric steam generators.
13,558. J. CAUDERAY. London. Improvements in unipolar continuous current magneto or dynamo electric machines.

August 12, 1891.

13,589. G. E. HEYL. Berlin, C., Germany. Improvements in electric conductors.
13,627. W. B. BRAIN and A. J. ARNOT. London. An improved alternating electric current motor.

August 13, 1891.

13,628. W. HARTNELL. Leeds. Improvements in dynamos for generating electricity.
13,657. H. NEHMER. London. An adhesive voltaic plaster.

August 14, 1891.

13,692. A. H. MITCHEL-JONES. Manchester. Improvements in electric arc lamps.
13,705. A. SHIELS. Glasgow. An improved coupling for connecting electric wires.
13,714. H. W. MILLER. London. Improvements in and relating to apparatus for measuring electric currents.
13,753. A. M. CLARK. London. Improvements in telegraphic call-boxes. (J. G. Noyes, United States.)
13,754. W. S. RICHARDS and G. B. JAMES. London. Improvements in and relating to electric tramways and to vehicles therefor.

August 15, 1891.

13,802. J. SOHLMAN. London. Improved electric current generator for ordinary and multiple phase alternating currents.
13,809. G. HUGHES. London. New or improved machinery for covering wire conductors with leather. (E. E. Legrand, France.)

SPECIFICATIONS PUBLISHED.

1890.

12,832. WILSON. Electrical meter. Price 8d.
13,845. HUBER and MAGEE. Propelling tramway vehicles, &c., by electricity. (Price 8d.)
13,987. RICHARDS and OTHERS. Electricity counter. (Price 8d.)
15,250. SOUTH. Electric circuit connections. (Price 8d.)
15,252. SOUTH. Incandescent electric lamps. (Price 8d.)
14,404. SNELL. Electrical switches. Price 8d.
14,411. NIBLETT. Secondary batteries. Price 8d.
14,484. EVERED and RUDLING. Electric switch, &c. Price 8d.
14,696. BAYLEY. (Treber). Telegraphic relay. Price 8d.
14,698. CROMPTON and CHAMEN. Electrical conductors. Price 1s. 3d.
14,830. WALTON. Accommodating electric wires in buildings. Price 4d.
14,992. HAWTAYNE. Electrical conductors. (Price 4d.)
16,279. SLAWIANOFF. Preventing defects in castings. Price 8d.
18,904. FRASER. Magneto-electric telephonic apparatus. Price 8d.
19,749. TURNER. Electric lamps. Price 8d.
20,329. WOAKES. Electrical transformers. Price 6d.
20,712. ORTELLI. Electric batteries. (Price 8d.)

1891.

2,219. LEVER. Electric arc lamps. (Price 8d.)
6,276. BLANCHARD. Electric cars. (Price 6d.)
7,353. BAYLY. (Weems). Electric railway systems. Price 8d.
8,941. BOULT (Ries). Electrical hardening, &c. (Price 11d.)

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9,762. CURRIE. Secondary batteries. (Price 8d.)
10,227. HOLMES. Electrical conductor. Price 4d.
10,695. ANGELL. Heating metal bars by electricity. (Price 8d.)
10,697. LAKE (the Thomson-Houston International Electric Company). Dynamo-electric generators, &c. (Price 8d.)

NEW COMPANIES, STATUTORY RETURNS, &c.

ANDERS, ELLIOT, AND CHETHAM-STRODE (LIMITED).—This Company was registered on the 11th August, 1891, with a capital of £5,000 in £1 shares, by E. J. Moeran, 89, Chancery Lane, W.C. The objects are: To acquire and take over as a going concern the business of electrical engineers and manufacturers of telegraphic and telephonic apparatus and appliances heretofore carried on by Anders and Elliot, at 10, Bush Lane, Cannon street, E.C., and Penarth-street, Old Kent-road, S.E., and with that view to carry into effect an agreement with C. H. Elliot and W. Chetham-Strode. To carry on the business of the above firm in all its branches, together with that of a Telegraph, Telephone, and Electric Light, Heat and Power Supply Company. The number of Directors is not to be less than two nor more than three, the first being C. H. Elliot, W. Chetham-Strode, and R. King, the first two being Managing Directors, with a salary of £200 per annum. Qualification of a Managing Director, £1,000; remuneration of ordinary Directors, £2. 2s. for each meeting attended. Office: 10, Bush Lane, Cannon-street, E.C.

F. W. BERK AND CO. (LIMITED).—Registered by W. H. E. Stone, Billiter-square-buildings, E.C., with a capital of £100,000 in £10 shares. Object: To acquire the undertaking of Messrs. F. W. Berk and Co., and to carry on in all its branches the business of importers, exporters, and manufacturers of chemical products, and other compounds appertaining thereto. None of the capital will be offered to the public.

BRITISH ELECTRO-CHEMICAL AGENCY (LIMITED). — This Company was registered on August 11, 1891, by Bonner, Wright, Thompson, and Co., Ingram House, 165, Fenchurch-street, E.C., with a capital of £75,000, divided into 2,500 vendors', and the remainder ordinary shares. The objects are: To enter into and carry into effect an agreement in the terms of a draft already prepared and expressed to be made between the Electric Construction Corporation (Limited) of the one part, and this Company for the other part, providing for the sale to the Company of certain patent rights. To purchase, or otherwise acquire, any other inventions relating to electricity, or the production or application thereof, or to any chemical, or electrical, or electrolytical, or electro-chemical process, or manufacture; or to any apparatus, implements, or machinery in connection with electricity; and to work and develop the said inventions, or any others that may be acquired. The number of Directors is not to be less than three, nor more than seven, the first being Mr. Joseph Ebbsmith, of Worcester House, Walbrook, E.C.; John B. Verity, of King-street, Covent Garden, W.C.; and J. Balfour, Savoy-hill House, W.C. Qualification, £250. J. Ebbsmith is the Chairman, and has a remuneration of £1,000 per annum. The remuneration of the other Directors is to be as follows: When less than 5 per cent. per annum is paid on the ordinary paid-up capital, £150 per annum each; when more than 5 and less than 10 per cent. is paid, £300 per annum each; when more than 10 per cent. is paid, £600 per annum each.

ELEKTRIZITATS-GESELLSCHAFT IN HAMBURG.—Under this title a Company has been formed in Hamburg, with a capital of M.1,200,000. The manager is Herr Hartogh, who has hitherto been the Hamburg representative of the Allgemeine Elektrizitäts Gesellschaft.

STEEL NUT COMPANY (LIMITED).—This Company was registered on August 11, 1891, with a capital of £5,000 in £5 shares, by Jordan and Sons, 120, Chancery-lane, W.C. The objects are: To carry on the trades or businesses of nut and bolt manufacturers, ironmasters, iron and steel manufacturers, manufacturers of screws, rivets, hinges, &c., tool makers, mechanical and electrical engineers. To acquire the undertaking of J. Hampton, the elder, and S. Partridge, trading under the name of the Patent Grinding and Polishing Machine Company, and to adopt a certain agreement, dated August 5, 1891, between J. Hampton, the elder, and S. Partridge of the one part, and J. A. Allen of the other part. The number of the Directors (unless otherwise determined) is not to be less than two nor more than five. Qualification, 50 shares. Remuneration, £50 per annum. J. Hampton and S. Partridge are the first Managing Directors. Solicitors: Slater and Co., Darlaston.

AKESTER ELECTRO-MOTOR AND ACCUMULATOR COMPANY (LIMITED).—The annual return of the above Company, made up to August 11, 1891, was filed on August 13th. The Company, which was registered on May 16, 1887, has a capital of £5,000 in £1 shares. All the shares have been taken up, and upon 1,500 16s. per share has been called. 3,500 shares have been considered as fully paid. The calls paid amount to £1,253. 8s., and unpaid to £46. 12s., £100 of which being paid in advance. Office: 36, Great James-street, Bedford-row, W.C.

BABCOCK AND WILCOX (LIMITED).—The registered office of this Company is situate at 114, Newgate-street, E.C.

BOURNEMOUTH AND DISTRICT ELECTRIC SUPPLY COMPANY (LIMITED).—An agreement made August 7, 1891, between the above Company and the Brush Electrical Engineering Company (Limited), cites that by a former agreement, dated June 4, 1891, between the same parties, it was agreed that the latter should sell, and the former should buy, the properties mentioned in that agreement, and in consideration, £17,275 in cash or fully paid-up shares, should be given to the vendors. The purchasers have agreed that the £17,275 is to be paid by the issue of 3,155 fully paid-up shares, and the balance in cash. The present agreement determines that on or before August 15, 1891, the shares mentioned above, and numbered 1 to 3,155, shall be allotted to the vendors or their nominees, and that the balance shall be paid in cash. (Filed on August 12, 1891.) Office: Observer Chambers, Albert-road, Bournemouth.

BYNG TELEPHONE COMPANY (LIMITED) (in Liquidation).—A meeting of the shareholders is to be held at 32, Mosley-street, Newcastle-on-Tyne, on September 17th, at 3 p.m., to receive an account of the winding up.

EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to July 30th, was filed on August 12, 1891. The Company, which was registered on August 19, 1879, with a capital of £400,000, has now a capital of £600,000 in £10 shares. All the shares have been taken up, the full amount called and all calls paid. The Eastern Telegraph Company (Limited) have taken 58,993 shares, and the Telegraph Construction and Maintenance Company (Limited), 600. Office: Winchester House, Old Broad-street, E.C.

EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED).—The annual return of this Company, made up to August 4th, was filed on August 10, 1891. The Company, which was registered on October 26, 1883, has a capital of £1,000,000, divided into 150,000 "A" and 50,000 "B" shares of £5 each. 89,261 "A," £3 paid, 17,139 "A" fully paid, and 23,564 "B" fully paid shares have been taken up, and upon the 89,261 "A" shares 10s. per share has been called and paid. The total amount agreed to be considered as paid on 89,261 "A" shares is £223,152. 10s., on 17,139 "A" shares £85,695, and on 23,564 "B" shares £117,820. The calls paid amount to £44,630. 10s., and the amount considered as paid is £426,667. 10s. Office: 100, Victoria-street, S.W.

ELECTRICAL ENGINEERING CORPORATION (LIMITED).—The office of this Company, which is in liquidation, is now situate at 58, Coleman-street, E.C.

EXCHANGE TELEGRAPH COMPANY (LIMITED).—The annual return of this Company, made up to August 12, 1891, was filed on the following day. The Company, which was registered on March 28, 1872, now has a capital of £246,250, divided into 8,125 "A" and 16,500 "B" shares of £10 each. 8,125 "A" and 16,200 "B" shares have been taken up, and upon 6,000 "A" shares £8 per share has been called and paid. £8 per share has been considered as paid on the remaining "A" shares, and the full amount on the 16,200 "B" shares, the whole amounting to £179,000. Office: 17 and 18, Cornhill, E.C.

GENERAL ZINC RECOVERY AND LIGHTING COMPANY (LIMITED).—At a meeting of shareholders held on July 14th, it was resolved, and at a meeting on August 7th it was confirmed, that the Company be wound up, and that Mr. J. M. Henderson, C.A., of 2, Moorgate-street buildings, E.C., be the liquidator.

IPSWICH ELECTRICITY SUPPLY COMPANY (LIMITED).—By an agreement made on July 2, 1891 (filed on August 12th), between Laurence, Scott, and Co. (Limited), and the above Company, the Ipswich Company agree to purchase the business of electrical engineers carried on by Laurence, Scott, and Co. at Norwich, Ipswich, and elsewhere, and in full satisfaction to pay them £1,069 in cash, and to allot to them or their nominees 1,431 fully paid-up £1 shares. Laurence, Scott, and Co. agree to abandon their Provisional Order under the Electric Lighting Acts 1882 and 1888, and the Ipswich Company will endeavour to obtain the confirmation of Parliament to their order. The Ipswich Company intend as soon as possible to increase their capital from £100 to £20,000. By an agreement made on July 2, 1891 (and also filed on August 12th), between the Brush Electrical Engineering Company (Limited) and the above Company, it is agreed that, in the event of the confirmation of Parliament to the Provisional Order of the Ipswich Company, the Brush Company shall have no interest in the other Company except as shareholders; and since the Brush Company have incurred expenses to the extent of £600 in connection with the application for the Provisional Order, and also in the promotion of the Ipswich Company, £50 in cash, £50 in cash within three months of the Parliamentary confirmation, and the allotment of 500 fully paid-up £1 shares, shall be deemed full satisfaction for all such expenses. Should the confirmation of Parliament not be granted, £50 fully paid up £1 shares shall be allotted to the Brush Company, or their nominees, in consideration of the said £600. Office: 112, Belvedere-road, Lambeth, S.E.

SHROPSHIRE ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—The capital of this Company has been increased by the addition of 100 founders' shares of £1 each to the registered capital of £25,000. The special resolution, of which the above is an abbreviated account, was passed July 2nd and confirmed July 27, 1891, and the notice to the Registrar of Joint Stock Companies was filed on August 13, 1891. Office: 9, The Square Shrewsbury.

SIEMENS BROTHERS AND COMPANY (LIMITED).—The annual return of this Company, made up to June 30, 1891, was filed on the same day The Company, which was registered on December 28, 1880, has now a capital of £500,000 in £100 shares. All the shares have been taken up and £85 per share been called thereon. All the calls are paid, amounting to £425,000. Office: 12, Queen Anne's-gate, S W. Alterations in the Articles of Association, Nos. 14 and 16, by special resolution, passed June 16, 1891, and confirmed July 6, 1891, were filed July 16, 1891.

TELEPHONE COMPANY OF AUSTRIA (LIMITED).—The annual return of this Company, made up to August 13, 1891, was filed on the following day. The Company, which was registered on April 27, 1883, with a capital of £100,000, has now a capital of £200,000, divided into 20,000 ordinary and 20,000 preference shares of £5 each. 11,703 ordinary and 7,358 preference shares have been taken up, and upon 150 of the ordinary, and the whole of the preference shares, the full amounts have been called and paid. The remaining ordinary shares have been considered as fully paid. The calls paid amount to £37,540, and the sum considered as paid is £57,765. Office: 53, New Broad-street, E.C.

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CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the past week were £4,261.

CITY AND SOUTH LONDON RAILWAY COMPANY.—The traffic receipts of this Company for the week ended August 16th amounted to £653.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended August 14th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company were £2,835.

THE ELECTRIC INSTALLATION AND MAINTENANCE COMPANY (LIMITED) (for the supply of electricity to the Crystal Palace, Sydenham, and district).—A prospectus of this Company was issued at the beginning of this week. The Company is established with a capital of £100,000, divided into 10,000 shares of £10 each, and we learn that the necessary capital has been privately subscribed. The Chairman of the Board of Directors is Colonel Lewis Vivian Loyd, D.L., J.P., and another Director is Mr. Joseph Pyke, who is also connected in that capacity with the London Electric Supply Corporation. The Manager is Mr. George Offor, the Secretary Mr. J. W. Barnard, and the Offices are at 4, Great Winchester-street, E.C. The objects of the Company will primarily be as follows:—(1.) To supply, by means of electric motors, the horse-power required by exhibitors at the forthcoming Electrical Exhibition at the Crystal Palace in the ensuing winter; and (2) To supply electricity for light and power purposes to the Crystal Palace and district surrounding it, under the powers contained in the Provisional Order granted them last year, and duly confirmed by Parliament. The engineers to the Company are Messrs. J. E. H. Gordon and Co., who also act as contractors, and who take three-fifths of the contract price of the works in shares and debentures. An arrangement has been entered into with the Crystal Palace Company by which the new Company will supply the first 400 H.P. required by exhibitors at the forthcoming Electrical Exhibition. A generating station is to be erected by Messrs. Gordon and Co. capable of supplying 400 H.P. to the Crystal Palace, and afterwards to supply electricity to 20,000 lamps. We must refer our readers to the prospectus for further particulars. The lists of applications opened on Monday last, and will close not later than 4 o'clock this day (Friday.)

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, August 12.		Price Wednesday, August 19.		Rate per Cent. Yielded. £ s. d.	Dividend Due.	Business Done During Week Ending August 19. Highest.	Lowest.
			TELEGRAPHS.								
£1,300,980	Stock	12/0	Anglo-American	43	44	45½	46½	5 18 3	Jan., Apr., July, Oct.	45½	43½
£2,849,510	Stock	24/0	Do. Preferred	82½	83½	84	85	6 9 5	" "	84⅞	83
£2,849,510	Stock	5/0	Do. Deferred	9½	10	10¼	10⅝	..	.. ..	10⅛	9⅝
£250,000	100	4⅞	African Direct, Telegraph 4% Debentures	99	102	99	102	3 18 5	January and July ..	..	..
130,000	£10	5/0	Brazilian Submarine	11¾	12¼	11¾	12¼	6 18 9	Mar., June, Oct., Dec.	12	11¾
£69,200	£100	5%	Do. 5 per Cent. Bonds	99	102	99	102	4 18 0	January and July ..	101¾	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103	107	103	107	4 13 6	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	105	109	105	109	6 3 10	April and October ..	108	..
16,000	10	8/0	Cuba Submarine xd	10½	11½	10	11	7 5 6	February and August	..	..
6,000	10	10%	Do. Preference 10% xd	17	18	16¼	17¼	5 14 3	" "	..	..
12,931	5	3/2⅔	Direct Spanish (£4 paid)	3⅜	4⅛	3⅜	4⅛	6 11 9	April and October ..	..	..
6,000	5	10%	Do. Preference 10%	9⅜	10⅛	9⅜	10⅛	4 15 3	" "	10⅛	9⅞
60,710	20	3/6	Direct United States	10⅜	10⅝	10⅜	10⅝	6 8 5	Jan., Apr., July, Oct.	10⅝	10⅜
400,000	10	5/6	Eastern	14½	14⅝	14½	14⅝	4 10 5	" "	14⅝	14½
70,000	10	6%	Do. 6 per Cent. Preference	15	15⅜	15	15⅜	3 17 5	" "	15⅜	15⅛
£1,203,060	Stock	6%	Do. 4 per Cent. Mort. Debenture Stock	107	110	107	110	3 12 9	May and November	109¼	108½
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	106	109	106	109	4 11 9	February & August	..	..
250,000	10	2/6	Eastern Extension	14⅝	14⅝	14⅝	14⅞	4 14 1	Jan., Apr., July, Oct.	14⅞	14⅝
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock	104	107	104	107	3 14 9	February & August	..	..
£85,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103	106	103	106	4 14 4	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	102	105	102	105	4 15 3	" "	102	..
180,227	10	4/6	Globe Telegraph and Trust	9⅜	9⅝	9½	9⅝	5 7 8	Jan., Apr., July, Oct.	9½	9⅜
180,042	10	6%	Do. 6 per Cent. Preference	14⅜	15⅜	14⅜	15⅜	3 19 4	" "	15	..
150,000	10	5/0	Great Northern	18½	19	18⅞	19¼	4 8 4	Jan., April, and July	18⅞	18½
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	106	109	106	109	4 11 9	March & September	..	..
17,000	25	37/6	Indo-European	39	41	41	43	5 15 3	May and November	42	..
38,348	10	5/0	London latino-Brazilian	6½	7⅛	6½	7⅛	6 0 0	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	107	110	107	110	5 9 1	March & September	..	..
9,000	8	4/0	Reuter's	8	8½	8	8½	4 14 1	April and October ..	..	..
3,381	£100 Cert.	£1	Submarine Cables Trust 6%	117	121	117	121	4 19 2	" "	119	..
15,609	10	6/0	West African Telegraph	8	9	8	9	5 11 1	January and July ..	..	..
£231,400	100	5%	Do. 5 per Cent. Debentures	96	99	96	99	5 1 0	March & September	97½	..
30,000	10	2/0	West Coast of America	2⅛	3⅛	2⅛	3⅛	..	January and July ..	..	..
£150,000	100	8%	Do. Debentures 8% 1902	97	102	97	102	7 16 10	June and December	93	97½
88,321	10	9d.	West India and Panama	1⅞	2⅛	1⅞	2⅛	..	..	..	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10	10½	10	10½	5 14 3	May and November	..	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9	10	9	10	6 0 0	" "	..	..
61,683	15	9/0	Western and Brazilian	10¾	11¼	10¾	11¼	6 13 4	" "	11¼	10¾
30,364	7½	1/6	Do 5 per Cent. Cumulative Preferred	6½	7	6½	7	5 7 3	"	6⅞	6½
30,364	7½	7/6	Do. 5 per Cent. Deferred	4¼	4¾	4¼	4¾	..	..	4⅝	4⅜
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	102	105	102	105	5 14 3	February & August	103½	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	101	104	101	104	5 15 5	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117	122	117	122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	101	105	101	105	5 14 3	March & September	..	..
			TELEPHONES.								
224,850	14/0	0/5¼	Consolidated Telephone Const. & Maintenance	7/8	15/16	15/16	1	..	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid)	7/16	1/16	7/16	1/16	6 3 11	Yearly	..	..
438,984	5	3/6	National	4⅛	4¼	4⅛	4¼	6 6 4	June and December	4 11/16	4⅛
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½	13½	12½	13½	4 8 11	" "	12¾	..
15,000	10	6%	Do. 6 per Cent. Cumulative 2nd Pref. (£8 pd)	12½	13	12½	13	3 14 1	" "	..	..
350,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd)	105	107	105	107	4 4 1	..	106	106½
58,000	5	1/0	United River Plate	2	3	1½	2½	..	January and July ..	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 8	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
1,000	£50	..	City of London Electric Lighting (£50 fully paid)	..	..	60	62	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	4½	5	4½	5	..	..	..	..
5,322	£5	..	House to House Electric	..	..	4½	5	..	..	..	..
30,000	£5	..	Liverpool Electric Supply (£3 paid)	..	..	2⅜	2⅞	3 13 1	..	..	..
111,000	5	..	London Electric Supply	1⅜	1⅞	2	2¼	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	9½	10	9½	10	..	..	9¾	..
7,730	£5	3/6	St. James' and Pall Mall	6¾	7½	6¾	7½	..	..	7	6⅞
..	..	7%	Do. 7% Preference	4¼	4¾	4¼	4¾	..	..	4 7/16	..
42,853	5	..	Westminster Electric Supply (£5 paid)	5	5⅛	5	5⅛	..	..	5⅛	5¼
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978		..	Brush Electrical Engineering	2⅝	2⅝	2⅝	2⅝	..	..	2⅝	..
69,996		6%	Do. 6 per Cent. Preference	1⅝	2	1⅝	2	6 0 0	June and December	1 13/16	1⅝
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	4	5	4	5	7 0 0	January and July ..	..	..
17,139	5	..	Edison and Swan United	..	..	..	..	..	..	..	..
45,000	10	6%	Electric Construction	2½	4½	3½	4½	..	—	4	3⅝
70,000	2	10/0	Elmore's Patent Copper Depositing	3⅝	3⅝	3⅝	3⅝	..	—	3⅝	3 7/16
20,000	5	..	Fowler-Waring Cables (£4 paid)	2	3	2	3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	19	20	19	20	5 0 0	February & August	19⅝	19½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	105	104	106	4 4 11	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	7½	8½	7½	8½	11 15 3	..	..	..
11,334	£10	5/0	Do. Preference	9¼	9¾	9¼	9¾	8 4 1	..	..	..
78,949	5	2/1½	Swan United (£3. 10s. paid)	4½	5	4½	5	6 19 10	May and November	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	44	46	43	45	5 6 8	March and July.....	44½	43½
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101	104	101	104	4 16 2	January and July ..	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£3 paid)	..	..	2⅞	2⅞	..	..	..	..
—	£5	..	Do. Preference (fully paid)	..	..	3¾	4	..	..	..	..
			RAILWAYS.								
50,000	£10	..	City and South London Railway	3	5	3	5	—	—	3⅝	3

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PROFESSOR VON HELMHOLTZ

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THE ELECTRICIAN:

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NOTES.

The Cardiff meeting of the British Association will not prove of great interest to electricians, as the Papers read were not very numerous, and, on the whole, possessed no striking merit. The chief event was the discussion on electrical nomenclature in Section A.

Mr. Swinburne's Paper on the Causes of Variation of Clark's Standard Cells contained the result of a great amount of patient work. Before the Clark cell can be accepted as a practical standard, the effect on its electromotive force of a number of minor influences must be thoroughly investigated. The fact that Lord Rayleigh and Mr. Glazebrook have obtained for the cells made up by them electromotive forces which agree much nearer than one-tenth per cent. is not a sufficient recommendation of the cell as a standard. The cells were set up, and the measurements made at intervals of several years, but the construction was probably carried out on identical lines, and the chemicals obtained from the same source. Under these circumstances such close agreement is to be expected when exceptional skill is used. The crucial test lies in a comparison of cells made up with ordinary care from materials obtained from different places, and it is in this connection that Mr. Swinburne's Paper is so valuable, for it describes in detail the effect of a number of the smaller circumstances influencing the electromotive force.

On Tuesday, Prof. Carey Foster read the annual report of the Committee of Electrical Standards. This Committee is the oldest of all those which have, from time to time, been appointed by the British Association, and it has done much valuable work. An evidence of its importance has but recently been given by the selection, by the Board of Trade, of a Committee on Standards to a large extent composed of those physicists who have been most prominent in the analogous work carried out by the British Association. Naturally, the report this year referred more especially to matters in connection with the electrical standards which are shortly to be legalised.

Incidentally, a point of some practical importance was raised in the discussion. Prof. Viriamu Jones, of Cardiff, stated that he had the means at his disposal to accurately determine, in absolute measure, the value of small resistances of about $\frac{1}{1000}$th of an ohm, and suggested that such standards might prove useful for commercial purposes. As Mr. Preece stated, there is a growing demand for a means of measurement of very large currents, such as are used in metallurgy and other electrical applications. Neither dynamometers nor ammeters can be conveniently made for very heavy currents, and the shunt method of connecting a sensitive instrument to the terminals of a low resistance placed in series with the main circuit, is by far the best to employ. In such cases a knowledge of the resistances, together with the sensitiveness of the instrument for weak currents, is sufficient to determine the magnitude of the strong currents to be measured, and it appears very probable that a demand will arise for accurately certified resistances of the character suggested by Prof. Jones, now it is known where such standards may be obtained.

In opening the discussion on "Units and their Nomenclature," a full report of which we hope to give in our next issue, Dr. Lodge directed special attention to the need for giving names to two units, viz., the unit of self-induction and either the practical unit of magnetic line density (B), or the practical unit of lines of force. The relative claims of *secohm*, *quadrant*, and *henry*, for the former unit, have already been discussed in these columns, and we need not further refer to them except to say that the word *quadrant*, although recommended by the Paris Congress and adopted by the British Association two years ago, has found but little favour in this country; and that none of the speakers during the discussion urged its adoption. The word *secohm* aims at being self-explanatory, and has proved very convenient as a temporary unit. Dr. Lodge points out that, if it were adopted, the *secvolt* would be the natural name for the unit of induction, this being such that if the number of lines of force through a coil were equal to five secvolts, and were removed in one second, the average electromotive force generated would be five volts. The word *henry*, however, appears to have the greatest number of supporters in England and America. It keeps green the memory of a distinguished physicist, and is a word which has already come into general use.

It does not, however, appear so desirable to name the unit of self-induction as the unit of magnetic field. The self-induction of a coil or armature expresses its magnetic properties, but not in a form most convenient or intelligible to the engineer, whose conceptions are based upon areas, magnetic fields, currents, and numbers of turns, so that a combination of all these, such as is self-induction, detracts from simplicity.

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Mr. Preece, who spoke immediately after the President, referred to the long efforts made by the Association to get the metrical system of units adopted in this and other countries, and very pertinently remarked that as the ohm, volt, ampere, and farad were to be legalised in the course of a few months, it was most desirable that no suggestions should be made tending to show that any doubt existed that these units were the best to have.

Prof. Stroud then proceeded to explain his "revolutionary" notions about units. On examination it appears regrettable that, when the practical system of units was originally adopted, the ohm and volt were chosen different multiples of the corresponding C.-G.-S. units. This was done in order that the unit of voltage should be about equal to that of an ordinary cell, and the unit of current of the same order of magnitude as the currents in common use at that time. The varied conditions of practice at the present day render these considerations of no account, and Prof. Stroud shows how the relation of the practical and the C.-G.-S. systems could be considerably simplified by one or two fundamental changes. It, however, does not appear to be worth while to make these alterations, as the great advantages of a metrical and inter-related system of units are secured without them, the exact power of 10 necessary to convert a unit from the C.-G.-S. to the practical system can very readily be found, and it is of but small importance that it has many different values, according to the unit chosen. As Mr. Swinburne pointed out, the enormous difficulties put in the way of practical men by making alterations in any established system of units are not properly appreciated. The advantages Prof. Stroud seeks for may be attained by altering either the absolute C.-G.-S. system, or the practical system of units. Both changes were suggested, but electrical engineers will be as unwilling to adopt the latter as scientists the former.

Mr. Geo. J. Stoney, who was one of the members of the original British Association Committee of 1874, pointed out that no consistent system of units could avoid including some of very inconvenient size. He had objected at the time to the introduction of the practical system in addition to the C.-G.-S. system, and had suggested, in preference, a consistent method of naming multiples and submultiples. There is much to be said for Mr. Stoney's views, the correctness of which is being demonstrated now that many other units besides the ampere, volt, and ohm are needed for practical purposes. It has several times been proposed to make the henry, the unit of self-induction, some submultiple of the secohm, on account of this unit being rather larger than is common in practice. It would, however, be a distinctly retrograde step to adopt any other value for the henry than 10^9 C.-G.-S. units, as this is the only value which can be used consistently with the other practical electrical units.

The discussion afterwards wandered on to the subject of dimensions, although the connection with nomenclature was by no means clear. Mr. Stoney pointed out a simple and useful way of expressing the nature of the various electrical quantities. Prof. Rücker explained his manner of describing the relation between electrostatic and electro-magnetic units, and Prof. Silvanus Thompson pointed out the desirability of distinguishing ordinary quantities from others in which the idea of direction was involved. Prof. A. Gray thought that the phrase electromotive force was unfortunate, but that it would cause much inconvenience to drop it. We thoroughly agree with him as to this expression, but the inconvenience of dropping it is not so great as he thinks. It is very rarely to be found in our editorial columns. The discussion was continued by Prof. Carey Foster, Mr. Blakesley, and Prof. J. Viriamu Jones, and, although it showed no signs of flagging, was brought to an end by some concluding remarks of the President.

The Paper of Mr. Preece on the London-Paris Telephone was of considerable interest, especially to the more popular part of the audience, but it did not contain very much information which has not already been given by the author elsewhere. It appears that the quality of the sound transmitted does not depend much upon the instruments employed, as all kinds and makes of transmitters and receivers have been used with about equally good results. To this, however, there is one curious exception. Microphone transmitters are found to give much purer sounds than magneto-transmitters, and Mr. Preece attributes the difference to the fact that with the former the current variations are not nearly so sinuous as with the latter.

The Committee appointed to study the phenomena of the discharge of electricity from points presented a brief report. The investigation here referred to originated in the work of Dr. Lodge in connection with the dissipation of fog, and many will regret that the research, which at one time promised to successfully solve an important practical problem, seems now to have resolved itself into the explanation of a number of interesting but rather abstruse matters. It was found at an early stage of the inquiry that charged points only dissipated electricity easily when placed in the neighbourhood of an opposing point or plate, and the behaviour of isolated points had to be thoroughly investigated before proceeding further. The work has been mainly carried out by Mr. A. P. Chattock, who presented to the meeting a rather lengthy Paper on the Electrification of Needle Points in Air.

After a considerable delay, for which no reasons have been suggested, the Electric Welding Company have issued their prospectus, and invite subscriptions for one-third of their capital, which is fixed at nearly half-a-million. It was expected that the promoters would have most appropriately struck the iron while it was hot, soon after the brilliant display of the process in Great George-street. The prospectus contains no new information of any importance, nor does it suggest on what scale the process will warrant the expenditure of capital in laying down a powerful engine and dynamo, besides the expensive welding machines, in place of an ordinary brick forge, a fan, and the simple tools used by the smith. We fear that the system

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of a royalty on each weld made will be very repugnant to English engineers, and while the prospectus says "the royalties are fixed at a very low rate," as though to induce *manufacturers* to adopt the system, it is admitted, for the encouragement of *investors*, that "in the aggregate they are expected to amount to a very large sum." It might have been supposed that after all that we have heard about this process in America, and the period that has elapsed since it was first pushed, that more than one hundred machines would have been already in use in the United States, but this is the figure given in the prospectus, and we are not informed if all of these have passed beyond the stage of experimental or tentative use. It is very obvious to any engineers who have watched the progress of electric welding that it is much better adapted to the wholesale rushing style of American manufacture than to the deliberate and ever-varying work which is done with us; and yet it is expected that in this country one hundred machines will "be got into use the first year" and one hundred and fifty further machines in the second year. Prof. THOMSON's machines are, as every one will admit, most ingenious and useful devices for special purposes, and their value is greatest when they are designed for and restricted to continual work on one job such as welding ends on boiler stays. Remembering that the patents cannot cover the general principle, we fear that the proposed mode of introducing electric welding into this country will not play so great a part in our commerce and manufactures as is suggested by this prospectus.

BY the death of Mr. RAIKES the Government has lost one of its ablest supporters, and the Post Office a much-respected chief. From the day of his appointment as Postmaster-General, in 1886, Mr. RAIKES not only assumed the headship of a great department, but actually directed and controlled it. Nothing was too small or too great for his conscientious industry to take in hand, or for his undaunted spirit to carry through. His loss will be greatly felt in every branch of the service, and if his successor has a lighter task before him than the one undertaken by his predecessor, it will be because the chief difficulties have been overcome, and the schemes of reform well nigh completed. For the *employés* of the Post Office Mr. RAIKES worked most strenuously, and succeeded in placing them on a footing which leaves no reasonable ground for discontent. It is the usual lot of Postmaster-Generals to be much abused; and Mr. RAIKES had, perhaps, more than his fair share of newspaper criticism. But when his achievements are candidly reviewed, it will be found that no man deserved public censure less. Perhaps no one felt it more; for when it is said that he died of overwork, we cannot dismiss from our thoughts the suspicion that over-worry may have had something to do with his untimely end.

THE correspondence which has been going on in the *Standard* relating to village industries and postal facilities may serve a useful purpose, if only to suggest the possibilities of rural industry. Long before such possibilities are realised, however, there will be no lack of postal and telegraphic facilities. At present, so far as can be gathered from the complainants' letters, there is no case of tangible hardship, except perhaps to individuals who furnish high sounding pretexts for their personal demands. That this is the literal truth is pretty evident from the indignant protests called forth against the guarantee required by the Post Office before extending wires to places where the telegraph business likely to be done would not be remunerative. If the applicants hesitate to guarantee so small a sum as is asked for, the inference is that nobody wants the telegraph but themselves. Less than 20 messages a week would cover the guarantee. No reasonable being can expect an expensive service to be established without evidence, to that extent at least, that the service is needed. At all events, where village industries are concerned—if any such there be—we may be sure they will have no difficulty in finding the money. Meantime it ought to be better known than it generally is that a telegram can always be *posted* to the nearest telegraph office, often reaching there in a few hours, and thus beating the through post by perhaps half-a-day.

Milan.—The Milan Central Station is now supplying about 22,000 glow lamps and 852 arcs.

Whitechapel District Board.—At the last meeting of this Board the Clerk was instructed to take the necessary steps to have a Provisional Order prepared and presented.

Electric Traction in Rome.—An application has been laid before the Town Council for a concession for working four new tramway lines in Rome by electricity, by means of an underground conductor.

Shrewsbury.—At the last meeting of the Town Council the application of the Shropshire Electric Light and Power Company for consent to their application for a Provisional Order was considered and the application was granted.

Arco.—The electric lighting of Arco, in the Tyrol, has been secured by the Vienna firm Kremenezky, Mayer and Co. Water-power to the extent of 200 H.P. will be used. The street lighitng is to be effected by glow lamps at 150 volts.

The Patent Office.—Mr. Leng, M.P., whose able speech on the subject of Patent Office administration we reprinted in our issue of July 17th, is engaged in getting up a petition to be presented to the Board of Trade praying for an alteration in the present scale of fees, &c.

City of London Electric Lighting Company.—We learn that the Board of Trade have given their final consent to the transfer to this Company of the Provisional Orders granted to the Brush Electrical Engineering Company and the Laing, Wharton, and Down Construction Syndicate.

Hamburg.—Tenders for the supply of electric energy in Hamburg will be received up to October 10th. The conditions under which the concession will be granted may be obtained on payment of five marks, from the Secretary to the Finance Committee (Rathans I. Stock, Zimmer No. 34).

Caledonian Telephone Company.—Under this name there has just been formed in Glasgow a Company which has as its aim the development of the private business in running telephone lines, and supplying French instruments, which was recently started by Mr. A. Erskine Muirhead, of that city.

Paris.—An inquiry, says our Paris correspondent, has been opened at the Préfecture de la Seine with regard to the proposed tubular electric railway, running across Paris from the Bois de Boulogne to the Bois de Vincennes. At present a railway journey between these two points involves a long *détour*, and takes an hour and a-half.

Church Lighting.—The old City church of St. Nicholas Cole Abbey is to be lighted by electricity. The rector says he has taken this step to relieve the congregation of "the insufferable atmosphere of the gas, which put the organ out of tune and the people out of temper, spoiled the colour on the walls and ceiling, and did harm to the health of not a few of us."

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Kingstown Town Commissioners.—At the last meeting of this body the following motion was passed unanimously:—"That the Town Clerk be instructed to advertise for tenders for lighting the township for one or three years with either electric light or gas. Tenders to be considered at the first meeting in October. The Town Clerk to prepare a detailed statement of the cost of lighting the township during recent years."

Glasgow.—The Glasgow Electric Light Committee yesterday agreed to recommend the appointment of Mr. Wm. Arnot, who is at present Electrical Inspector to the London County Council, as Electrical Engineer under the Corporation. Mr. Arnot has, we understand, had considerable experience in both high and low-tension systems of electric lighting work in London and Plymouth, as well as at the Grosvenor Gallery Station. He had for some time the management of the engineering department of Messrs. Latimer Clark, Muirhead and Co.'s works.

Mexican Government Telegraph Receipts.—The growth of telegraphic traffic in Mexico, through the development of the country, is steadily increasing the revenue receipts under that head. The total revenue under the head of Telegraphs is still small, but it is growing at a satisfactory rate, the increase during the past three years having been nearly 100 per cent. The following comparison is taken from the official revenue returns for the last four fiscal years:—

1886-7.	1887-8.	1888-9.	1889-90.
$197,498	$275,856	$329,493	$388,926

British Association.—According to the *Times*, soon after the conclusion of Prof. Silvanus Thompson's popular lecture on "Electricity in Mining," given on Wednesday evening in the Park Hall, Cardiff, an accident occurred. Prof. Thompson had on the platform a coalcutter, which was set in motion after the lecture. A man got upon the platform, without permission, and put his right foot over the revolving rod. The projecting spikes instantly cut into his leg just above the ankle, and broke the bone. He was laid hold of and dragged away before he was further injured.

Edisonia.—Under the title of "Edisonia" the *Electrical Engineer*, of New York, publishes, with its issue of August 12, a survey of the Edison Light and Power Industries, in the shape of an elaborate special supplement of some twenty pages. The illustrations, typography, and general get-up of "Edisonia" are of the excellent description characteristic of American work in this direction; and, had the text contained more "esoteric details," and fewer quotations from Charlotte Brontë, Tennyson, Dryden and Shelley, the supplement would have been as interesting as it undoubtedly is artistic.

The Electrical Utilisation of Water-power in Bavaria.—A company has been formed in Lindau under the name of the Elektricitätswerk der Argau, for the purpose of supplying Lindau, Langenargen, Friedrichshafen Tettnang, Ravensburg, Weingarten, and Wangen, with electric light and power. At a meeting recently held, Herr Huber, of the Maschinen Fabrik Oerlikon, recommended the adoption of the rotary current. About 3,000 H.P. will be available for distribution. It is estimated that the yearly charge for 1 H.P. will not exceed £6 or £7, and that lamps will cost about £1 or 25s. per annum.

The Lauffen-Frankfort Transmission Plant.—Our Frankfort correspondent telegraphs that the Lauffen-Frankfort transmission is expected to be in regular operation at the end of the present week. The line is finished and tests are being made. A number of glow-lamps, in series, are set up on a frame to show the reality of the pressure at which the current is transmitted (20,000—25,000 volts). The posts supporting the line are all adorned with skulls and crossbones, and have the warning notice, "Don't touch," painted on them. On Wednesday motors were driven by the current from Lauffen.

Sheffield Technical School.—We have received the 1891-92 prospectus of this Institution. Although, of course, the greatest attention is devoted to the metallurgical department, other studies are not neglected. The total number of students on the registers during the past session was 518, as against 197 for 1889-90. The following extracts from the Principal's report will show that those responsible are imbued with the true spirit of technical education:—"It has been the earnest desire and aim of the promotors of the School, from the beginning, to provide a school for the scientific study of steel, which should be worthy of this great centre of the steel industry. This object is now an accomplished fact, and Sheffield may be congratulated on possessing the most complete School of Metallurgy in existence. . . . The applications for places in the metallurgical laboratories are in excess of the accommodation, and *the students in this department are chiefly those actually engaged in some branch of the steel trade.*"

Brighton.—At the last meeting of the Town Council it was announced that the supply of electricity would commence not later than September 15th. Considerable discussion arose with regard to the tender of Messrs. Sharp and Kent for wiring and fitting the central station for electric light. The Lighting Committee reported that, on August 4th, they had accepted the tender of Messrs. Sharp and Kent to perform the work in accordance with the specification prepared by Mr. Shoolbred for the sum of £189. 15s.; but that, at a further meeting held on August 10th, Mr. Shoolbred reported that Messrs. Sharp and Kent had withdrawn their tender of £189. 15s., and had made an amended offer to do the work at the price of £204. 15s., and that it was resolved to accept the amended tender. Councillor Nell said he thought it a bad example to allow a tender to be withdrawn after acceptance, and a higher price added, and Alderman Sendall moved the exception of the proceedings. The exception was then put and carried.

Cable and Land Line Interruptions and Repairs.—

	Date of Interruption. 1891.	Date of Repair. 1891.
Ceara-Pernambuco Cable*	Mar. 14	—
Cape St. Jacques-Thuan An-Haiphong Cables*	June 28	—
Saigon Bangkok Line	July 22	Aug. 14
" "	—	" 17
" "	Aug. 18	" 19
Moulmein-Bangkok Line	July 25	" 3
Bahia-Rio-de-Janeiro Cable	" 24	July 30
" "	" 31	Aug. 6
Siberian Lines	July 26	July 27
"	Aug. 10	Aug. 10
Transandine Line	July 28	July 28
" "	Aug. 4	Aug. 5
" "	" 17	" 18
" "	" 19	—
Suakim-Djedda Cable*	" 6	—
Gibraltar-Tangiers Cable*	" 12	—
Mollendo-Arica Cable	" 13	Aug. 21
La Paz-Arica Line	" 13	" 21

* Not yet repaired.

Bridges Operated by Electric Power.—One of the latest American applications of electric power is the operation of swing-bridges. In Chicago a bridge, weighing about 800 tons, 240ft. long, and 59ft. broad, is worked in this manner. Heretofore power had been obtained from an engine and boiler perched 20ft. above the roadway of the bridge, between the main trusses. When these and the heavy gearing connected with the steam mechanism are discarded, it is estimated, says the *Western Electrician*, that the saving in weight will amount to about 40 tons. The current is furnished from the station of the Chicago Arc Light and Power Company. The motor has been thoroughly tested under every circumstance, and has proved satisfactory. A similar draw-bridge is the Grand Avenue Bridge in Milwaukee. This is 180ft. long and 35ft. wide, and weighs 200 tons. Before the introduction of electricity this bridge was operated by hand, and it could not be swung to allow a vessel to pass in less than five minutes. Now one man can control the operation of it with perfect ease, and at the same time make a quarter turn in 30 seconds. The equipment of both bridges, both mechanical and electrical, was carried out by the Thomson-Houston Company. The Milwaukee bridge has worked satisfactorily for two months.

Some Lately Manufactured Telephone Cables.—In the *Electrical World* of August 15th, Mr. Herbert Laws Webb has some corrections to make in an article on this subject by Mr. Perrine, which appeared in our New York contemporary, and was reproduced in our last issue. "When we come," Mr. Webb remarks, "to the speaking limit of the Roebling cable, there is a far more startling difference between Mr. Perrine's figures and the true ones. The cause of the error is that Mr. Perrine

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has taken the K R *per mile*, instead of making it the product of the *total* resistance into the *total* capacity of the cable. It is a very simple error, and one that has often been made before, always, of course, with the same wonderful results that are obtained in this case. Taking the New York cable, Mr. Perrine finds that according to Jacques' formula we could speak 736 miles with a Blake transmitter, and 1,650 miles with a Hunnings. . . . Taking the capacity at ·081 microfarad per mile, and the resistance at 34·95 ohms, the speaking limit would be as follows:—

Jacques' limit for Blake transmitter...KR = 2,000 27 miles.
" " " Hunnings " ...KR = 4,500 40 "
Preece's " " underground work KR = 8,000 54·2 "

Such figures as 27 miles, 40 miles, and even 54·2 miles, look very insignificant beside such considerable distances as 736 miles and 1,650 miles."

The Electrical Trades' Section and the Frankfort Exhibition.—We are asked to state that the Sub-Committee recommends that gentlemen joining the party in connection with the Electrical Trades' Section of the London Chamber of Commerce should travel *viâ* Dover and Ostend, leaving Holborn Viaduct Station by the train at 10 o'clock, a.m., on Saturday, the 5th of September. Each member of the party should provide himself with the necessary travelling ticket, and it is recommended that such tickets be obtained through Messrs. Cook and Son, Ludgate-circus, E.C., the fare being, *viâ* Dover and Ostend, £5. 16s., first class return, available for 30 days. The ticket should be taken on or before the 2nd of September, and, in the event of this being done, Messrs. Cook and Son will engage reserved railway carriages between London and Frankfort, and members are requested to specify that they belong to the Electrical Trades Section party. Members are further notified that ladies may be included in the party. With regard to hotel accommodation the Sub Committee could not well engage definitely sufficient rooms beforehand for the entire party, but the Committee suggests to members to adhere to the following suggestions, in which case they will, no doubt, be suited for rooms. They can either buy coupons for rooms and dinners through Messrs. Cook and Son, for the Swan Hotel, Frankfort, and if such coupons are taken at the same time as the ticket Messrs. Cook will take steps to reserve sufficient and good accommodation. Or members of the party can secure rooms at the Britannia Hotel or Hotel Romkscher Kaiser, if they write to the proprietors about a week beforehand, mentioning that they belong to the Electrical Trades' Section party. The Committee is in communication with the President of the Electro-Technical Society of Frankfort with respect to tickets for the various events in connection with the Exhibition and Congress, and gentlemen will be advised, if necessary, as to what special arrangements can be made in this respect. Any further information that may be required can be had on applying to the Chamber of Commerce.

The Telegraphs of Nicaragua.—The United States Consul at Managua, writing with regard to the telegraphic service of Nicaragua, says:—"The year 1862 saw the dawn of the telegraph system in the Republic of Nicaragua. The first line was constructed by the Transit Company between the ports of San Juan del Sur, on the Pacific coast, and Virgin Bay, on Lake Nicaragua, and was 15 miles in length. The line was afterwards abandoned by the Transit Company, and, so far as is known, nothing was done towards the system until the year 1876. In this year the Nicaraguan Government employed a Costa Rican to commence the construction of a national line. During this year 190 miles of telegraph were erected, and offices opened for the transaction of business in the principal cities. The line during the year 1879 was extended to Jinotepe, a distance of 12 miles, and communication established between Somotillo and Choluteca. On June 24, 1880, the port of San Juan del Sur was connected with Liberia (Costa Rica), uniting the lines on the frontiers of the two Republics. The line was reorganised in the latter part of the year 1880. An extension was made into the gold-mining district of Chontales. The frontiers of Nicaragua and Honduras were united, in 1882, by the construction of a line between Ocotal and Paraiso. It being found that the business of the country could not be properly transacted by the line then in operation, the Government erected a second line between Granada, Masaya, and Leon, these being the principal business centres of the Republic. During the year 1882 an office was opened at San Juan del Sur by the Submarine Cable Company. The year 1886 witnessed the introduction of the telephone system between Acoyapa and San Obaldo, the length of the line being 15 miles. As the country was steadily growing in population and commerce, it became necessary to extend the telegraph system, and, in 1887, the line was extended to Managua, Masaya, and Granada, a distance of 33 miles. Another line was added, in 1888, between Mometombo and Leon. The total number of miles of telegraph lines erected during the year 1889 was 334; telephone lines built for same period were 56 miles. Since 1888, 250 miles have been built, at a cost of $38,434·80. The line has also been prolonged from San Carlos, at the junction of Lake Nicaragua and the San Juan River, to Castillo, on the same river, a distance of 45 miles. This extension was made necessary on account of the location of a Custom House at the latter point. Here the National Line joins that of the Canal Construction Company, which extends to San Juan del Norte, on the Atlantic coast, a distance of 95 miles, and has seven offices on the route.

Obituary.—Mr. Edward Gilbert, whose death was recently recorded in the Dundee papers, was long and intimately identified with telegraph work abroad as well as at home. A native of Oxford, he was in early life in the service of the Electric and International Telegraph Company, snd by diligence and perseverance he rose in the service until he was appointed superintendent for the northern district, his headquarters being the city of Aberdeen. While he was in this employment he served under Mr. Cromwell F. Varley and Mr. W. R. Culley. In 1864 Mr. Gilbert was offered and he accepted the position of Telegraph Superintendent of the Scottish North-Eastern Railway Company, and the district over which he had control extended from Aberdeen to Perth and Dundee, and covered a large portion of the ground included in the system of the Electric Telegraph Company. His new position was, therefore, a somewhat difficult and delicate one, and he was often called upon to deal with matters somewhat antagonistic to his old employers, but by his tact and ability he managed to settle intricate questions without the least friction. When the Scottish North-Eastern Company was, in 1866, amalgamated with the Caledonian Company, Mr. Gilbert was continued in his old position, but in the following year he was induced to transfer his services to the North British Railway Company, a change which led to his removal to Edinburgh; and while resident there he distinguished himself by the manner in which he carried on the work of his department. When, in 1868, negotiations were opened between the Government and the various railway companies for the acquisition of the telegraph system by the State, Mr. Gilbert was requested to take a prominent part on behalf of the North British Railway Company, and the agreement which he eventually drew up on behalf of that company was the basis of all the settlements which followed. The agreements then made are still in force, and probably the most important feature of them for the railway companies is the privilege which they have of sending messages over the Government wires free of charge. In 1874 Mr. Gilbert resigned his appointment with the North British Railway Company, and accepted the position of Superintendent-in-Chief of Telegraphs for the Japanese Government. While in Japan he re-organised the telegraph system of that country, and during the five years that he remained there he was instrumental in putting the service on a very satisfactory basis. Returning to this country, towards the end of 1879, Mr. Gilbert was offered the post of Manager and Secretary of the Dundee and Arbroath Joint Railway. He continued in that post up till his death.—We regret to record the death of Sir Thomas Fairbairn, Bart., which occurred on the 12th instant, at his country seat, at Bishopstoke, near Southampton. Sir Thomas, who was born in Manchester, in 1822, was connected with the Associated Submarine Telegraph Companies. The funeral took place at Twyford, near Bishopstoke, on Tuesday, the 18th, and many of the deceased's friends and old associates were present.

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ON THE ELECTRO-MAGNETIC THEORY OF THE ROTATION OF THE PLANE OF POLARISED LIGHT IN A MAGNETIC FIELD.*

BY PROF. A. GRAY, M.A.

Sir William Thomson has explained the turning of the plane of polarised light in a magnetic field by supposing the ether to have imbedded in it a large number of small gyrostats, having the undisturbed positions of their axes in the common direction of the magnetic force, and the propagation of the beam, and all rotating in the same sense. When, in consequence of the vibratory motion, each gyrostat has its axis of rotation displaced from this direction it reacts on the surrounding medium with transverse force at right angles to the plane through the axis of rotation and the direction of motion.

By compounding this stress with the elastic forces of displacement of the ether, differential equations of motion are obtained which are of precisely the form necessary to account for the difference in rate of propagation of the two circularly polarised rays constituting the plane polarised ray.

The equations thus found are of the form

$$\rho\frac{\delta^2\xi}{\delta t^2} = n\frac{\delta^2\xi}{\delta z^2} + c\rho\frac{\delta^3\eta}{\delta t\,\delta z^2}$$

$$\rho\frac{\delta^2\eta}{\delta t^2} = n\frac{\delta^2\eta}{\delta z^2} - c\rho\frac{\delta^3\xi}{\delta t\,\delta z^2}$$

where ξ, η, denote component displacements of a portion of ether in two rectangular directions perpendicular to that of z taken as the direction of propagation, p, the density of the ether, in its proper elastic constant, and c a constant depending in the rotating matter.

It is suggested by the gyrostatic investigation that it ought to be possible to explain the magneto-optic rotation on the electro-magnetic theory of light, as a consequence of the existence of the small magnets which are supposed imbedded in the medium with their axes in the direction of propagation of the ray, and, therefore, producing the magnetisation of the medium on that direction.

In consequence of the motions of the ether, the directions of the chains of magnetised molecules, which are supposed to exist along the direction of magnetisation (here taken as axis of z), in the undisturbed state of the medium, are continually undergoing change at every point, and thus the direction of the axial magnetic force along each chain also undergoes alteration. It is obvious that if the displacements be everywhere small the actual magnitude of this force will sustain only a comparatively small percentage of alteration, but that each such small change of direction will produce a component magnetic force in each of the two directions at right angles to the axis. The calling into existence of these components will produce corresponding electromotive forces tending to increase or diminish the electric displacement.

The electromotive force in the direction of y is given in Maxwell's notation by

$$Q = -\frac{dG}{dt} - \frac{\delta\psi}{\delta y}$$

where dG/dt stands for the total time-rate of change of G, the component of vector potential in the direction of y, and δ denotes partial differentiation. Also since H, the component along z, does not perceptibly vary along x, if the direction of propagation be as taken here along z, $-\delta G/\delta z$ denotes magnetic induction through unit of area in the plane of yz. Hence any part of the total time-rate of variation of $-\delta G/\delta z$ will denote the space-rate of variation, in the direction of z, of an electromotive force parallel to y, provided the time and space differentiations of the part are commutative. This result is to be borne in mind in what follows.

Now, if the displacement of the ether particles from the undisturbed positions be taken as parallel and proportional to the electric displacement, and C be the component of magnetisation of the substance in the direction of z due to the existence of the molecular magnets, then, considering the electric displacement f in the direction of x, the component magnetic force in the direction of x will be, approximately, $e\,C\,\delta f/\delta z$, and thus the magnetic induction through unit of area in the plane of yz is $\mu e C\,\delta f/\delta z$, where e is a coefficient of proportionality. The time-rate of variation of this is

$$\mu e C\frac{\delta}{\delta t}\times\frac{\delta f}{\delta z}$$

But we have by the equations of electric currents

$$\frac{\delta f}{\delta t} = \frac{1}{4\pi}\left(\frac{\delta\gamma}{\delta y} - \frac{\delta\beta}{\delta z}\right) = -\frac{1}{4\pi}\frac{\delta\beta}{\delta z}$$

since there is no conduction current.

Further, by the relation of magnetic force to vector potential, $\beta = (\delta F/\delta z)/\mu$, and therefore the last equation becomes

$$\frac{\delta f}{\delta t} = -\frac{1}{4\pi\mu}\frac{\delta^2 F}{\delta z^2}.$$

Now, since the differentiation of f with respect to t is partial only, we may use the substitution

$$\frac{\delta}{\delta z}\frac{\delta f}{\delta t} = \frac{\delta}{\delta t}\frac{\delta f}{\delta z}.$$

Hence differentiating $\delta f/\delta t$ with respect to z we find

$$\mu e C\frac{\delta}{\delta t}\frac{\delta f}{\delta z} = -\frac{e C\delta^3 F}{4\pi\delta z^3},$$

which gives an electromotive force in the direction of y of amount

$$-\frac{e C\delta^2 F}{4\pi\delta z^2},$$

since there can be no constant or arbitrary time function concerned. Hence we have, finally,

$$Q = -\frac{\delta G}{\delta t} - \frac{e C\delta^2 F}{4\pi\delta z^2} - \frac{\delta\psi}{\delta y}$$

and therefore

$$\frac{\delta Q}{\delta t} = -\frac{\delta^2 G}{\delta t^2} - \frac{e C\delta^3 F}{4\pi\delta t\,\delta z^2}.$$

But the displacement current in the direction of y is dg/dt, and this is $K/4\pi.\delta Q/\delta t$. Also by the equations of currents $\delta g/\delta t = -I/4\pi\mu\delta^2 G/\delta z^2$. Therefore we have the equation

$$\frac{K}{4\pi}\frac{\delta Q}{\delta t} = \frac{\delta g}{\delta t} = -\frac{1}{4\pi\mu}\frac{\delta^2 G}{\delta z^2},$$

which, used in the equation already found for $\delta Q/\delta t$, yields

$$\frac{\delta^2 G}{\delta t^2} = \frac{1}{K\mu}\frac{\delta^2 G}{\delta z^2} - \frac{e C\delta^3 F}{4\pi\delta t\,\delta z^2}.$$

Similarly for the other component in the case of circularly polarised light we find the equation,

$$\frac{\delta^2 F}{\delta t^2} = \frac{1}{K\mu}\frac{\delta^2 F}{\delta z^2} + \frac{e C\delta^3 G}{4\pi\delta t\,\delta z^2}.$$

These two equations are identical in form with those given by the gyrostatic theory, and, of course, lead to the same results; that is to say, the plane of polarisation of an electromagnetic beam would show a turning effect in a magnetised medium.

The fundamental assumption here made that f, g, h are proportional to the ether displacements seems a reasonable one, and is in accordance with the view generally held (but not yet, perhaps, proved) with respect to the electro-magnetic propagation of light. If the above theory be otherwise satisfactory, it gives some support to that view.

The theory given above has been suggested by a reference in M. Poincaré's "Théories de Maxwell," to a note by M. Potier, in his French translation of Maxwell's Electricity, in which a theory apparently of this nature is given. I have not seen M. Potier's note, and it is possible that it has completely anticipated the present Paper.

* Abstract of a Paper read before the British Association, in Section A, Cardiff, August, 1891.

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THE FRANKFORT EXHIBITION.—VIII.

(FROM OUR SPECIAL CORRESPONDENT.)

In respect of number and importance of their exhibits, Messrs. Siemens and Halske are certainly the foremost in the Exhibition; they occupy a large space on the right of the Machinery Hall and have made their exhibits here, as elsewhere in the Exhibition, thoroughly representative of the work of the firm. We give below an illustration of their large continuous-current machine, and the steam-engine to which it is coupled. It is by far the largest direct-current dynamo yet constructed. The armature has an outer diameter of 9ft. 10in., while the stellate magnet has an outer diameter of 8ft. 11in. The machine is built for a full load of 900 H.P., at 100 revolutions. In the Exhibition, however, it is coupled direct to a 600 H.P. engine by Kuhn, which runs at 75 revolutions. The stellate magnet is bolted to the bed-plate of the steam-engine, its other support being that for the bearings of the armature. The machine is 10-poled, and has 10 sets of brushes. As will be seen from the illustration the brushes are in direct contact with the armature itself. The chief advantages of this arrangement are the comparative ease with which the armature can be examined, faults detected, and the rapidity and ease of repair. The brushes are in sets of three. In Darmstadt, where there are two 100 H.P. interior-pole machines by this firm in operation at the central station, the brushes, which are of the same description as those employed here, have not yet been renewed, although two years in use. The brush-holders are constructed so that each individual brush can be adjusted independently when the machine is running, while all the brushes may be simultaneously shifted or lifted by the device shown in detail in Fig. 2. The insulation of the armature wire not bared to the brushes is simply thin paraffined fibre. The machine charges a battery of 168 Tudor accumulators, having a capacity of 540 H.P.H., and also drives two electric cars shown by the firm; for this latter purpose the current is transformed up to 300 volts by a continuous-current transformer.

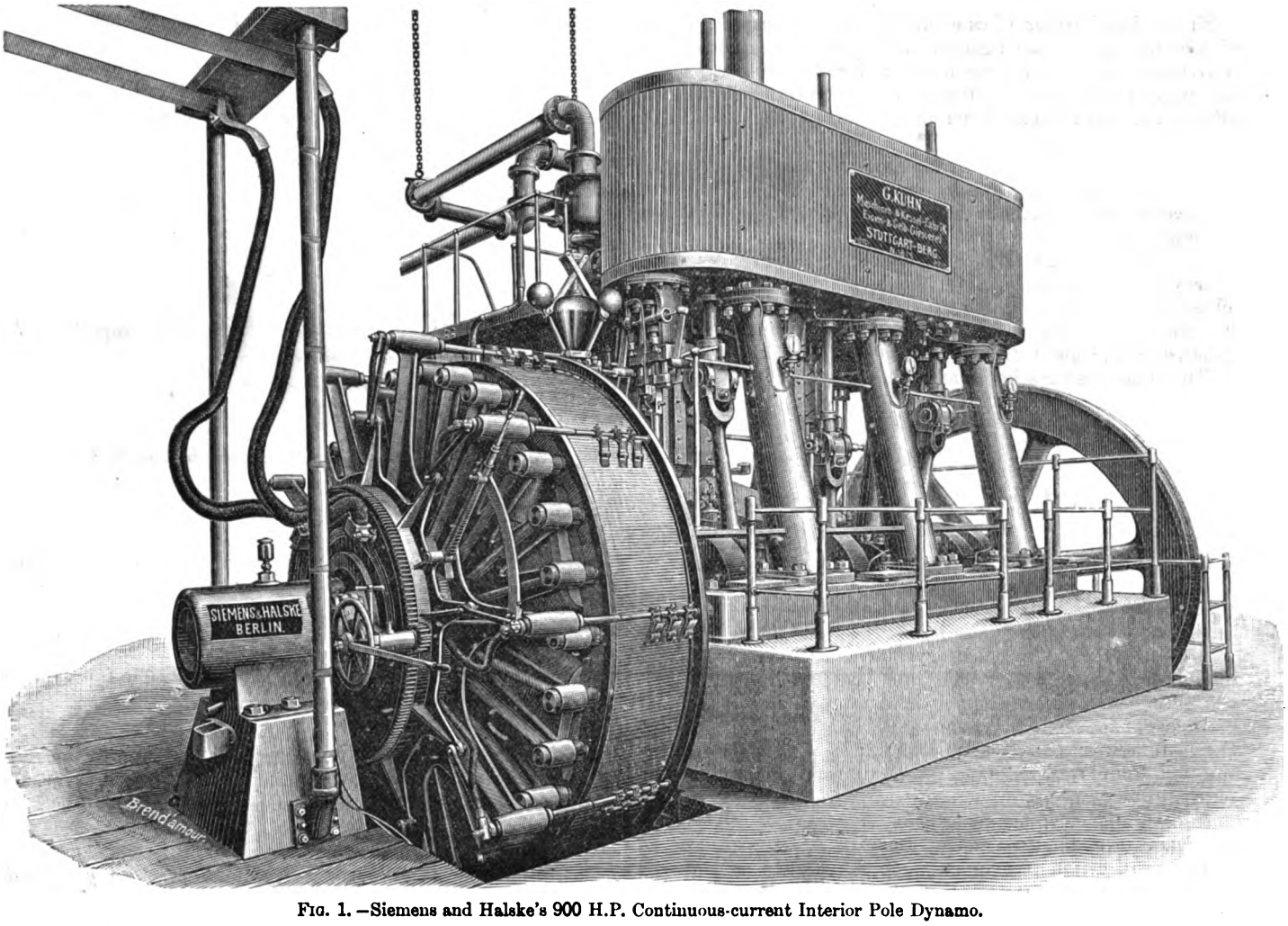

FIG. 1.—Siemens and Halske's 900 H.P. Continuous-current Interior Pole Dynamo.

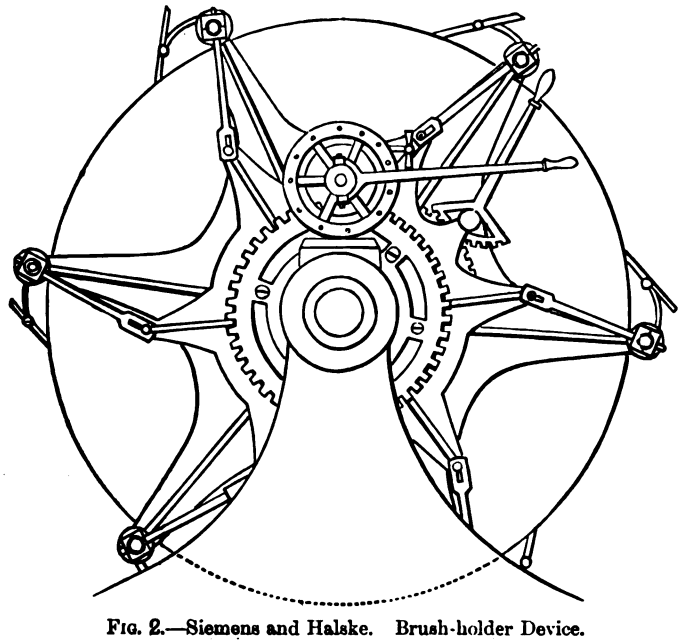

FIG. 2.—Siemens and Halske. Brush-holder Device.

The steam-engine to which the dynamo is coupled is by G. Kuhn, of Stuttgart-Berg. It is a triple-expansion condensing engine; the cylinder diameters are 1ft. 7½in., 2ft. 4in., and 3ft. 11in., and the piston stroke is 2ft. The steam pressure is from 150lb. to 180lb. per square inch. The engine was designed for an output of 600 H.P. when running at 120 revolutions, 500 H.P. at 100 revolutions, 400 H.P. at 80 revolutions. The high, medium, and low pressure cylinders are provided with steam jackets.

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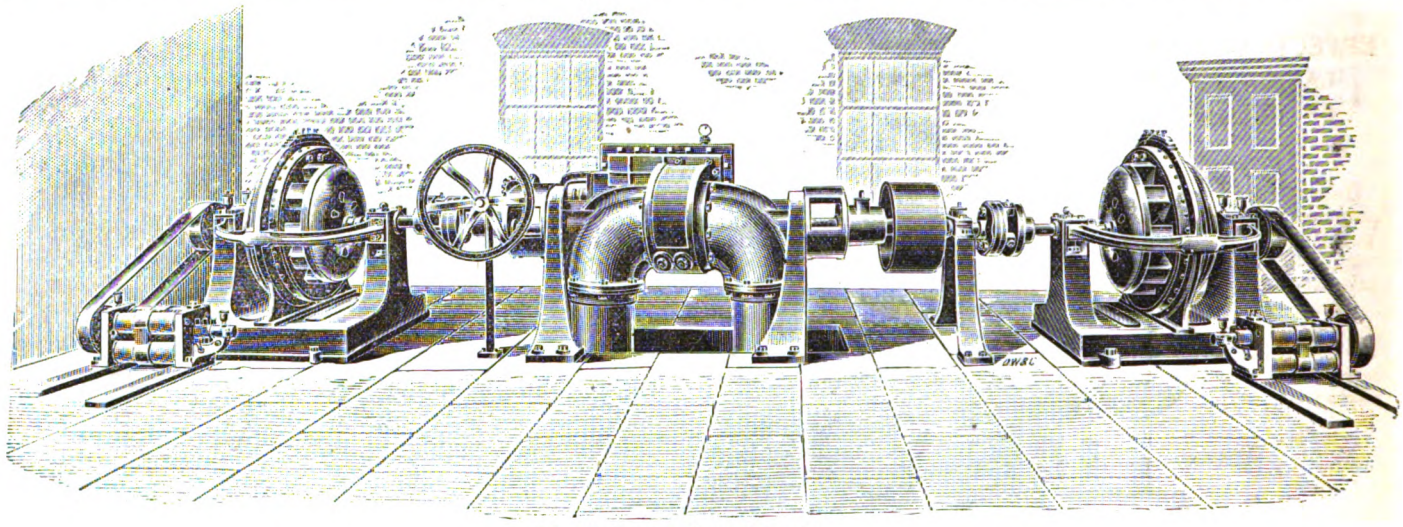
THE LYNMOUTH CENTRAL STATION.

Water-power stations are so few and far between in this country that a few particulars with regard to the small but interesting installation at Lynmouth, North Devon, may be of interest. The Lynmouth station has now been for some time in successful operation, the power being obtained from the River Lyn. The water of the River Lyn is diverted into an open conduit and thence into an iron pipe, 30in. in diameter and 1,700ft. in length, the available fall of water being 95ft. This fall of water is conducted to a 14in. turbine, capable of yielding 200 H.P. The horizontal shaft of the turbine is coupled direct to two Mordey alternators of the 37-unit size, running at 650 revolutions per minute. The exciting current is furnished from two small direct-current Victoria machines belted on to the shafts of the alternators (*see* Fig.) The electric lighting station is a small stone building on the bank of the East Lyn, the water being returned to the river when it has done its work. The current is supplied from the alternators at a pressure of 2,000 volts, partly by underground and partly by overhead mains. Each of the 37-unit alternators employed is capable of maintaining 1,200 or 1,300 8 c.p. lamps, all burning at one time.



The Lynmouth Central Station.

THE ANDREWS PENDANT SWITCH.

In reply to an inquiry which appeared on p. 431 of our last issue, Messrs. J. D. F. Andrews and Co., of Parliament-street, have sent us the following particulars of a switch which they think fulfils the requirements of our correspondent, who wanted "a reliable pendant switch composed solely of earthenware or other incombustible and non-hygroscopic material, with the necessary metal parts."

In outward appearance Messrs. Andrews's switch resembles a gas tap rather than an electric switch. The handle may be turned either way to make or break the circuit, the current being on when the tap is parallel with the centre line, and off when the tap stands at right angles. The internal construction is shown in Figs. 1 and 2. The contacts *c c* (Fig. 1) are insulated from the case by a new insulating stone called "alabite," which is moulded into position in the box with suitable dies under pressure, the contacts being fixed in the composition in one operation. The contacts *c c* are the terminals of the break in the circuit to be closed by the switch, and they are bridged by a disc, *d* (Fig. 2), which is actuated by the cam mechanism *a*. By turning the tap the pin *p* rises on the cam, forcing the disc on to the contacts, and is retained in that position under pressure by means of the spring *s*. The contact disc is insulated from the cam by a mica washer. The spring *b* throws the disc out of contact with a snap when the handle is turned to off.

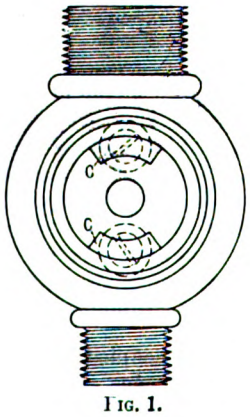


Fig. 1.

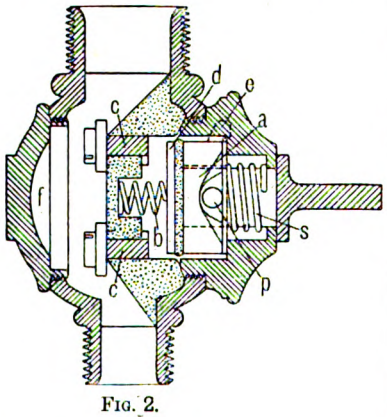


Fig. 2.

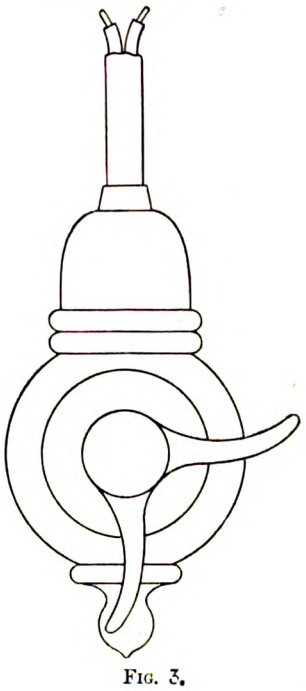


Fig. 3.

The sharpness of the break of the circuit is quite independent of the person operating, there being wide freedom in the slot *e* in which the guiding pin of the cam works. The connections of the wires are made by two screws, one to each contact at the back, which are got at by removing a cover, *f*. To enable

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the switch to be easily turned with one hand when in connection with a light flexible cord, a form of handle is made, as shown in Fig. 3, which is worked by resting the thumb on the bottom knob and turning the handle with the first finger. This form of switch is intended to be used separate from the lamp attached to a flexible cord. The switch is also made in one piece with a bayonet socket lamp holder. The sample which has been sent to us is intended for use with concentric conductors.

A practical test was recently made with one of these switches. The handle was connected to the works shaft with a 75 volt lamp in circuit and the current made and broken 36,000 times. No detrimental wear was visible.

EFFECTS OF HIGH TEMPERATURES UPON THE INSULATION RESISTANCE AND INDUCTIVE CAPACITY OF VULCANISED INDIA-RUBBER.*

BY WILLIAM MAVER, JUN.

In some of the streets of New York City an abnormally high temperature exists under ground, caused by defective pipes of the New York Steam Company. In certain ducts and manholes of the electrical subways in the locality heated by the steam pipes, the temperature has been found to range at times from 110°F. to 200°F.

To ascertain the effect the writer undertook a series of tests, the results of which are shown in the accompanying diagram. Tests were also made at the same time to ascertain the effect of high temperatures upon the inductive capacity of vulcanised india-rubber, the results of which are also shown.

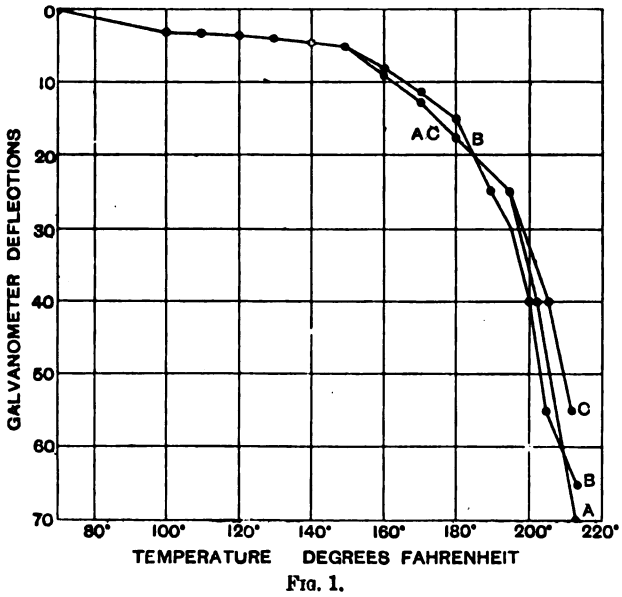

Fig. 1.

The cables tested were three in number, A, B, C, in the diagram, each 100ft. in length. The cables originally belonged to one piece, The conductor was ·097in. in diameter. The outside diameter of the insulating material was ·350in., approximately $\frac{11}{32}$; hence the thickness of the insulating wall was ·126in.

Cable A was unbraided and not lead covered.
Cable B was unbraided and lead covered.
Cable C was braided and lead covered.

This arrangement of the cables was chosen purposely to learn the effect, if any, of such coverings in diminishing the effects due to high temperatures.

A Thomson reflecting galvanometer was used. The readings for the capacity tests, in each case, taken at "charge"; those for the insulation resistance after one minute's electrification, that is, one minute after the depression of the charging key. Preliminary tests of the cables had shown the insulation resistance to be 1,500 megohms per mile at 70°F.

The working constant of the galvanometer at the time of tests, was 35,000 megohms. Hence (Fig. 1) it will be seen, for example that the total insulation resistance of cable A fell from 7,000 megohms at 150°F. to 500 megohms at 212°F.; that of cable B, from 7,000 megohms at 150°F. to 538 megohms at 212°F.; that of cable C, from 7,000 megohms at 150°F. to 636 megohms at 212°F. Calculated per mile, the insulation resistance of A would be at 150°F., 132·5 megohms; at 212°F., 9·5 megohms; that of B at 150°F., 132 5 megohms; at 212°F., 10·02 megohms; of that of C at 150°F., 132·5 megohms; at 212°F., 12·4 megohms. It is, however, unlikely that such high temperatures as these will ever be met with over a continuous extent of territory amounting to one mile. In practice such temperatures have not hitherto been found to extend continuously for more than 50 or 100ft. Hence, assuming the normal insulation resistance of a cable practically similar to those tested to be as stated, 1,500 megohms per mile, it may be observed that even with a 100ft. section of the cable exposed to a temperature of 212°F., the cable, as a whole, would show an insulation resistance of, approximately, 450 megohms per mile. From the results of the tests it may also be seen that any one foot of the cable would possess at 212°F. an insulation resistance of, approximately, 63,000 megohms, while any one inch of the same cable would possess an insulation resistance of 756,000 megohms at the same temperature.

Concerning the effect of ordinary changes of temperature on the electrostatic capacity of conductors, Kempe states: "The exact

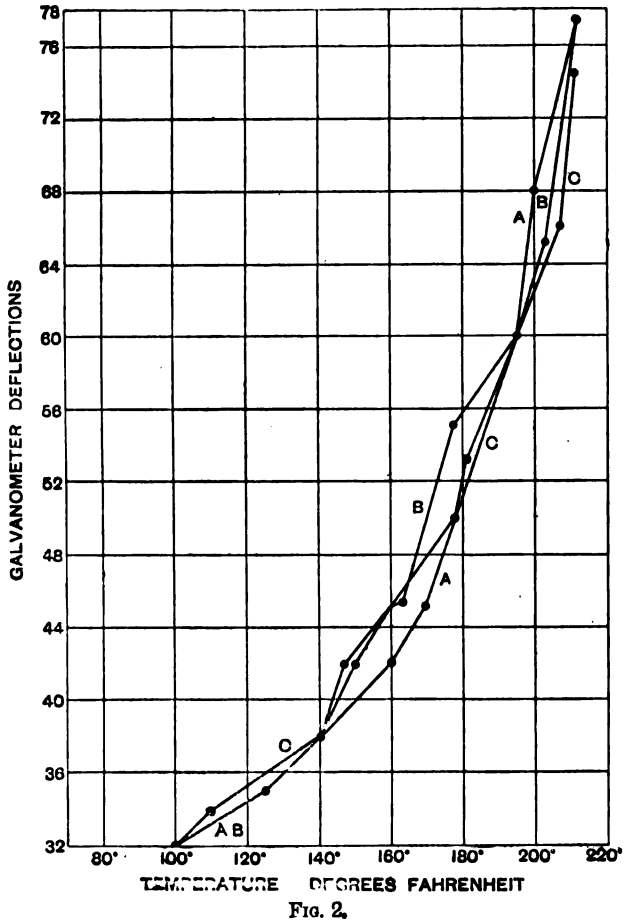

Fig. 2.

effect has not, it is believed, been yet determined or published." The capacity tests of the cables in question, as will be seen by reference to the "capacity" curve in Figure 2, indicate a marked increase in the inductive capacity of the insulating material between the temperatures of 100°F. and 212°F., namely, an increase of nearly 140 per cent. The capacity of C at the boiling point was somewhat less than that of A and B; which result, it is assumed, indicates that the cotton braiding acted, measurably, as a non-conductor of heat. It may be noticed also that, in both the insulation and capacity tests, the curves for C indicate a more uniform effect due to the increasing temperature.

The foregoing tests, which extended over a period of six hours, were made while the cables were immersed in water in a vat. The temperature of the water was gradually raised to the boiling point. The final tests were made after the cables had been subjected to the boiling temperature for over one hour. Immediately after the final tests the temperature of the water was reduced to the normal, when it was found that the insulation resistance and capacity of the cables were again practically normal.

It may be of interest to note that for over one year "high" potential electric light circuits have been successfully operated through ducts in the "heated districts" of New York City, and without any perceptible deterioration in the insulation resistance of the cables.

* From the *Electrical Engineer* of New York.

† We have divided Mr. Maver's single diagram into two separate ones with a view of making the curves more clear.

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The Electrician.

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THE BRITISH ASSOCIATION.

The Cardiff meeting of the British Association has attracted fewer members than any other meeting of recent years, the associates and members being numerically but little more than half those attending the Newcastle meeting two years ago. Perhaps the falling off may be partially attributed to the change of date, which is earlier this year by nearly a month than is usually the case, but the steady decrease in numbers on the last three or four occasions indicates the necessity for some effort being made to revive public interest in the Association's proceedings. The social success of the meeting was unfortunately much impaired by the unfavourable state of the weather, and, to many, an attractive feature of these gatherings was lacking, owing to the marked absence of several of the more prominent leaders of electrical science.

The Presidential addresses were quite equal in interest and power to those of previous years. The very able address upon astronomical subjects, given by the President, Dr. HUGGINS, does not call for much remark here, as it is of only indirect interest to electricians. The inter-connection between electrical and other sciences is, however, exemplified in more than one part of the address, as, for instance, when the possible dependence of terrestrial magnetism on the sun is alluded to. In this connection it may be of interest to recall the fact that, in 1889, Prof. SCHUSTER showed that the diurnal variations of terrestrial magnetism had to be attributed to a cause external to the earth's surface, and there can be little doubt that the sun is in some way the source of them. Mr. FOSTER BROWN'S address to Section G on mining operations was noteworthy for the preference he declared in favour of the use of electrical plant, while Dr. LODGE'S address to Section A was remarkable for the boldness and originality of the suggestions made. It rarely falls to the lot of a President to have the opportunity of calling attention to an important advance science, and the great majority of Presidential addresses accordingly consist of little more than learned and dull summaries of old matter. Few people have the courage to enter upon highly controversial subjects before a scientific assembly, but Dr. LODGE is evidently one of these few. His views as to the extension of science in other directions than those already recognised are boldly expressed, but they are probably shared to some extent by the majority of people, while at the same time there is a strong and unreasonable prejudice against investigation in certain directions. It is the plain duty of physicists to investigate the forces of nature, and if certain unexplained forces exist, or are said to exist, the problems which Dr. LODGE indicate will one day have to be faced. The idea of a National Laboratory is more tangible, but its chance of life

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seems but small. Apart from the great difficulty of endowment, the character of its work is rather vaguely defined. It would no doubt prove useful for experiments needing a long time to carry out, but it is difficult to forsee the theoretical or practical value of such work which not unfrequently ends in a negative result. It is also only sometimes true that "discoveries lie along the path of extreme accuracy." This is the case with mathematical subjects, such as certain branches of physics, and in astronomy, but not of the great majority of subjects.

We have alluded in another column to the principal Papers read, and the discussions following them. As regards the arrangements in general we can only emphasise the observations we made last year in reference to the meeting at Leeds. The Papers are far too numerous to be properly dealt with in the short time allowed for them, and the custom of carrying on the meetings for four hours without any interval results in a general thinning of the audience at lunch-time, which is necessarily most annoying to those whose Papers appear late on the programme. The audiences at Sections A and G are never large, and when they dwindle from 20 down to some half-a-dozen the situation simply becomes ridiculous. The adoption of a short luncheon interval would much improve this state of affairs, and the value of both Papers and discussions would be greatly enhanced if a limit was put to the number of Papers, and if these were set up in type and distributed previous to the meeting. Scientific Papers are difficult to follow when read, and it often happens, owing to obscureness of style, that the more valuable the Paper the less its merit is appreciated when heard for the first time. To criticise a Paper under these circumstances is next to impossible, and the barren nature of most of the discussions which take place at the British Association meetings is not to be surprised at.

When the subject of discussion is known in advance the result is quite different. Thus the joint meeting of Sections A and G, for the purpose of considering the nomenclature of the various electrical and mechanical units, is one which those present will remember for the great interest and vigour of the discussion which arose. The practical result of it was nevertheless disappointing, owing to want of organisation. The subject is a huge one, and no attempt was made to confine the discussion to definite points, and each speaker dwelt mostly upon matters of special personal interest, instead of directing his efforts to support or combat any distinct issues. The discussion was maintained with undiminished vigour until it had to be concluded from lack of time; but the result of it all was only too truly summarised in the words of the chairman when he stated that, as the subject was now fairly *opened*, he hoped that it would be taken up vigorously by the scientific press throughout the country in order that by *next year* some definite result might be arrived at.

HERMANN VON HELMHOLTZ.*

(Concluded from page 439.)

The problems which v. Helmholtz attacked when he applied delicate physical methods to the investigation of the time relations of muscular contraction and of nervous acts are so full of interest as to merit a passing notice, even in so brief a summary as that we are able to give.

"A moment" is the popular expression for an immeasurably short space of time. v. Helmholtz showed that the muscular contraction which physiologists designate "a simple muscular contraction," and which the non-scientific person would pronounce an instantaneous act, lasts about one-tenth of a second, and is, therefore, more than one thousand times as long as a flash of lightning. "Quick as thought" expresses the popular conception of inconceivable speed. The older physiologists shared the popular idea. Thus we find Johannes Müller stating in the last edition of his text-book (1844, Vol. I., p. 551):—"Stimuli act instantaneously throughout the whole length of the nerves, and throughout all their fibres, irrespective of the point of stimulation." Basing his opinion on the researches of Du Bois Reymond, Johannes Müller inclined to the opinion that nervous force and electricity were identical. As early as 1845, Du Bois Reymond had worked out the plan of estimating the speed of muscular and nervous activity by the method which Pouillet had devised for measuring exceedingly short intervals of time. He, however, had hesitated to carry out this plan, fearing much that this method of research would not be applicable for measuring such great velocities through such short paths. Five years later v. Helmholtz, by means of Pouillet's method, as well as by a graphic method, estimated the mean rate of transmission of nervous activity in the motor nerves of the frog, and found it to be 26·4 metres per second, or less than 10 times slower than the velocity of sound in air, or about equal to the rate of an English express train. In the course of these researches, he enriched physiological experimental methods by his myographion.

In the very next year (1851) v. Helmholtz astounded the scientific world by his discovery and description of the ophthalmoscope, for examining the retina in the living eye, "an optical instrument, by the aid of which it is possible to see exactly, and to recognise, in the living eye, the retina itself and the images of luminous objects thrown on it." By this discovery v. Helmholtz raised ophthalmic medicine to the position of a scientific study, and made it possible to save the eyesight of thousands of human beings. This magnificent discovery, too, was not due to direct inspiration. Already, in 1847, Cuming and Brücke had explained the conditions under which the interior of the eye appears luminous, and a Bernese doctor, von Erlach, had succeeded in illuminating the fundus of the eye by means of his spectacle glasses. But it is just the characteristic of the far seeing intellect of v. Helmholtz that it recognises the importance of things which even men of the calibre of a Du Bois Reymond or a Brücke pass by, with open eyes. In this respect he resembles Theodor Schwann, his celebrated predecessor with Johannes Müller; he surpassed Schwann, however, in his thoroughness, which led him always to test his work, "and not to leave it until it is impossible to improve upon it. It is work of this kind, which, by the classic completeness of its methods, and by the accuracy and reliability of its results, deserves and obtains the best and most lasting fame."*

It was by work of this kind that v. Helmholtz worked out and elaborated physiological optics, in the first instance discovering the nature of the act of accommodation by the employment of new methods, and especially by the use of the ophthalmometer (1853). Afterwards, when Professor of Anatomy and Physiology in Bonn (1855), he investigated the composition and action of the spectral colours. Ten laborious years he devoted, mostly, to his "Text Book of Physiological Optics" (1856-1866). In this work he made it "his duty to test and verify all essential points by his own observations and experiments." Thus, this work has become, as it were, a Bible to both the physiologist and the ophthalmic surgeon.

The great men who at that time, together with v. Helmholtz, laid the foundation of the modern German Physiological School, E. H. Weber, C. Ludwig, E. du Bois Reymond, and Brücke, had obtained for this science an independent position. It had come to be recognised that physiology must be separated from anatomy, and Du Bois Reymond had avowedly claimed for it the proud aim of ultimately merging into physics and chemistry. The new Chair of Physiology in the University of Heidelberg

* Since the first part of this article appeared, the interesting fact has been communicated to us that the mother of Prof. v. Helmholtz was the daughter of a Hanoverian Artillery officer of the name of Penne, a lineal descendant of William Penn, the renowned founder of Pennsylvania.

* These words of praise v. Helmholtz applied to the great physicist Magnus, his predecessor in the Chair which he afterwards filled in the University of Berlin. (Speeches: Vol. II., p. 40.)

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was offered to v. Helmholtz, and accepted by him. It was in Heidelberg that he displayed a new aspect of his high genius. He there produced his work entitled "The Doctrine of Tone Sensations as a Physiological Basis of the Theory of Music." "Music," said v. Helmholtz, "stands in a much nearer relation to pure *sensations* than any of the other arts, which have rather to do with *perception*—that is, with the conceptions of external objects—these being the results of psychical processes originating in sensations." Poetry obtains assistance only in a minor degree from music, *e.g.*, in its rhythm, "but tone painting depends directly on the sensory endowment of the ear." "In painting, colour is an element which is directly taken up by sensory perception." "The artistic pleasure given by a marble statue does not arise from the sensation of the white light which it sends into the eye, but rather from the conception of the beautifully formed human body which it represents." "Tones and tone sensations act quite independently of their relation to any external objects."

Pythagoras was well acquainted, from the ancient teachings of the Egyptian priests, that harmony—"the perfect consonance"—is produced when strings whose lengths (material and tension being the same) are in the ratio 1:2, or 2:3, or 3:4 are sounded together. They then sound the octave, fifth, or fourth. Nowadays, measurement is not expressed in terms of the length of strings, but of the number of vibrations, and by this means the laws of harmony can be tested on all musical instruments. To these consonances have been added the major and minor third (4:5 and 5:6). But what has pleasurable sensation to do with simple numerical ratios? Does a foot-rule give us any pleasure? V. Helmholtz had already put forth the fundamental ideas of his theory in popular form in 1857 in a lecture he gave at Bonn "On the Physiological Causes of Musical Harmony." His sequence of ideas was essentially as follows:—The ear separates those wave-forms which flow to it, if not already simple (*e.g.*, the note of a tuning-fork), into a number of simple waves, and feels these separately as simple notes, and does this whether the wave originated as such from the source of sound, or was compounded on the way. It is the grooved basilar membrane in the cochlea, an organ comparable to a harp in structure, which gives the ear the capability of doing this with the greatest accuracy and certainty. If a mixed note hits them, all those string-like portions of the membrane, whose individual parts correspond in vibration number to the single tones in the note are thrown into vibration, just as a number of strings in a piano (with the dampers off) vibrate, if a vowel is spoken into it. Besides the fundamental tone, the overtones are also heard.

The vibrations of two notes, but slightly different in pitch, strengthen and weaken each other periodically; we hear waverings, beats, grating; rough dissonance. In a similar manner, but not so markedly, neighbouring overtones interfere with each other. "Harmony and discord differ in this: in the first the tones flow away easily, each by itself, whilst in discord disturbances occur, and the tones are divided up and collide with each other. "Artistic instinct unconsciously discovers the nature of the artistically beautiful." In a word, v. Helmholtz discovered the hidden law which governs the musical character of harmonic tone combinations. In the course of these researches, he thoroughly traced out the mechanism of the auditory ossicles (1867 and 1869) and enriched philology with the theory of the formation of vowels. He showed that the principal difference between vowel sounds and those of most musical instruments is that the strength of their over-tones depends not only on their serial number, but chiefly on their absolute pitch, and that the various vowels are distinguished by the difference in the strength of their over-tones. By altering the length, width, and form of the cavity of the mouth, the speaker is able to give the strength to the dominant overtones which characterise the vowels he desires to utter.

Besides the physiological researches which have been briefly referred to, v. Helmholtz turned his attention to others closely connected with them. In optics he developed our knowledge of the horopter; in muscle physiology he investigated the muscular sound, and he added to the physiology of nerves by extending the researches which he had made on the rate of transmission of impulses in the nerves of the frog to the motor nerves of man. Moreover, in conjunction with his pupils, he now attacked problems of the highest interest to psychology, problems which had obtruded themselves on his attention in the course of his investigations on light and sound. Thus he measured, by strict physical methods, the time required for the perception of the effects of external stimuli, as well as the time occupied in the simplest mental processes.

The interest which v. Helmholtz manifests in branches of philosophy other than psychology is shown by the scientific scrutiny to which he subjected the axioms of geometry ("Collected Essays," Vol. II., p. 610; "Letters," Vol, II., p. 1). In the course of his researches on the representation in space of the system of colours, as well as on the origin of the power which the eye possesses of estimating magnitude, he had arrived at the conclusion that the axioms of geometry possess no *à priori* significance. As is matter of common knowledge, certain of these axioms assert that—(1) a straight line is the shortest path between two points; (2) a plane can be drawn through any three points in space which do not lie in the same straight line; (3) two lines are termed parallel if lying in the same plane, they never intersect; (4) through a point outside a given straight line but one line can be drawn parallel to the given line. Besides these, geometrical axioms give expression to statements determining the number of dimensions of space, its surfaces, lines, and points, and explanatory of the idea of continuity, *e.g.*, the boundaries of a body are its surfaces, of a surface a line, of a line a point, and a point is indivisible. Further, that by the motion of a point a line is described, by the motion of a line a line or surface, by that of a surface a surface or solid, but by that of a solid only a solid. All this is unproved, and did not seem to need proof as long as the only method of geometry was that of Euclid and his followers ("Lectures," Vol. II., p. 6). But if dimensions of another kind than the Euclidian are imaginable to the mathematical mind, this would be "proof that geometrical axioms are not necessarily conclusions from an *à priori* transcendental form of conception, in Kant's sense of the word" (p. 22). "Every comparison of size, be it estimation or measurement of relations in space, starts from an assumption regarding the physical properties of certain natural bodies, be it of our own forms or of the measuring instruments employed; and, although this assumption is exceedingly probable, and is entirely in concord with all that is known of physical properties, it certainly goes beyond the region of pure conceptions of space." "So that geometrical axioms make assertions, not merely in regard to the properties of space, but also in regard to the mechanical behaviour of the most rigid bodies during motion" (p. 29). "These are facts attained by accumulated experience, like many propositions which have seemed to metaphysicians to be of *à priori* nature. Here, as throughout all his studies, we find v. Helmholtz endeavouring to trace the original cause of phenomena. In the case of the complicated processes of life, with which physiology deals, this is difficult, and generally impossible. It was but natural that the intellectual tendencies of the exact investigator should predispose him to accept the Chair of Physics in the University of Berlin, which had just become vacant by the death of Magnus (1871). From this time forward he was engaged chiefly in inquiries in the great departments of electricity and hydrodynamics, The attempt had been made by celebrated physicists and mathematicians, like W. Weber, Riemann, and Clausius "to explain electrodynamic phenomena by the assumption of forces acting at a distance between two portions of the hypothetical electrical fluid, the intensity being dependent not alone on the distance but also on the velocity and acceleration."* The general mathematical formula of "the law of potential" for the strength of induced currents had been deduced from Ampere's law by the Nestor of Königsberg, F. E. Neumann.

At the time of its discovery, Newton put forth his great law of gravitation, which was to hold together the solar system, with hesitation and diffidence. The idea of forces acting in the absence of intermediate points of action, although then so daring, seems now self evident. Faraday again raised the

* "Lectures," Vol. II. p. 283.

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discussion on the problem whether forces exist acting at a distance without an intervening medium, by his remarkable discoveries of the phenomena of induction, rotation of the plane of polarisation by magnetisation, dielectric polarisation of insulators, and of diamagnetism. He concluded that every portion of space through which the magnetic force acts is in a permanently altered condition, in a state of tension which tends to return to its original condition as soon as the magnetic influence ceases, and that every alteration in this condition is manifested by the appearance of electromotive forces. Maxwell worked out the new theory mathematically and showed the possibility of regarding electricity, magnetism, and light as merely different states and motions of the same medium (the ether).

The aim of v. Helmholtz in this direction "had been to determine in what direction experiments should be made to decide between the various theories. He succeeded in making such an experiment on the electricity collected on the surface of a conductor rotating in the magnetic field. This experiment decided in Faraday's favour."* The second great problem whose elucidation Faraday had in mind, namely, the relation between electrical and chemical forces, stimulated v. Helmholtz to a series of important investigations. He formulated Faraday's law in this way :—"Through every cross-section of an electrical conductor there is always equivalent electrical and chemical motion" (*loc. cit.* 295). He then investigated this motion and the forces expended on it. He was able by means of the mechanical theory of heat, to calculate (in the case of a solution of salt), the effect of the water on the electromotive force. In this way he came to the investigation of the thermo-dynamics of chemical process and solved the general problem—what portion of the energy present in any system can be transformed into another kind.† He arrived at the result that all chemical compounds below their dissociative temperature give off heat, if produced in the reverse manner." In a highly ingenious manner he showed the reflex effects of the ether and ponderable atoms on each other, in his work on "The Theory of Abnormal Dispersion."‡

Having in 1888 already shown the remarkable analogy of the vortex motions of water with the electro-magnetic effects of electric currents,§ he now applied the theory of friction of solid bodies to that of flowing extremely thin films of fluids, and thus created an analogy between electro-dynamics and hydro-dynamics (1879).‖ He also introduced the conception of "Electrical Convection," viz., "The Transmission of Electricity by the Movement of its Ponderable Conductors" (1876). He showed that the law of constancy of energy makes it possible,¶ without the aid of any hypothesis as to the internal constitution of electrically or magnetically polarised bodies, to find the effect of the pondero-motor forces acting on the interior of such bodies, and causing changes of form. The conclusion is that the hypothetical system, assumed by Faraday, of tensions acting along, and pressure at right angles to, the lines of force, actually exists and acts in such bodies.

In his studies on the statics of mono cyclic systems** he added to mechanics the new idea of "Kinematic connection" (where the kinetic energy is the integrating denominator), *e.g.*, between bodies of the same temperature, or two tops whose axes are so connected that they must preserve the same rate of rotation.

In another essay†† v. Helmholtz thought the "principle of least action" was the general law governing all "reversible natural processes," and as regards the irreversible processes, *e.g*, the production and conduction of heat, it appears that the irreversibility is not intrinsic, but depends more on our limited means of action, since these do not allow us to bring back displaced atomic motions to their initial condition, or to effect the exact reversal of all atoms engaged in thermal motion.

The motion of fluids had already interested v. Helmholtz greatly at the time of his first acoustical investigations. He had investigated theoretically the motions of vortices in 1858, and confirmed the results in a few simple cases by experiment. Dove had shown that the constant change of weather, to which we are subject, was due to reciprocal alterations of cool dry polar winds and warm damp equatorial winds. In a lecture given in 1875* on cyclones and thunderstorms, v. Helmholtz explained the mechanical relations of wind currents, one upon another. Later on, he gave a mathematical investigation of atmospheric movements.† Starting from Euler's hydrodynamical differential equations, he came to the conclusion that the chief resistance to the circulation of the atmosphere lay not solely in its friction against the earth's surface, but rather in the mixing of different moving strata of air, leading to the formation of vortices. At the Cape d'Antibes he made observations on the energy of the waves and wind. The results obtained were that a wind lasting a considerable time gradually gives up some of the energy of its lower layers to the water. Wave systems of different length are thereby formed, and by their interaction (just like the formation of combination tones), stationary waves of greater length and velocity are formed. The wind can give up energy to the waves as long as its velocity is greater than theirs.

Lightning is explained in the above-mentioned lecture somewhat as follows :—The earth is permanently charged with (probably negative) electricity. Air and water vapour (not fog) are electrical non-conductors. Only when the clouds unite to form rain, and thus allow their water masses to come near enough together to allow of discharge from drop to drop, do they form one mighty conductor into which enormous sparks, lightning, can pass from the earth. The rain appears on the earth after the lightning, because it takes so much longer to fall than the time occupied by the electrical discharge. It is not at all impossible that a fire, or the thunder of the cannon in battle, should bring about a storm. If a state of unstable equilibrium already exists in the atmosphere, any circumstance which will cause the first small portion of the damp, warm, mass of air to rise may act the part of a spark in a powder magazine, and direct the chief discharge to the spot of this primary disturbance. We cannot hope ever to be able to forecast the weather. For small primary errors do not produce simply small errors in the results, because the item of unstable equilibrium enters into the conditions.

Though we have only touched but briefly on some of the most important of the researches of our great master, our survey, as yet far from complete, will have convinced the reader that scarcely a region throughout the whole domain of nature has been left altogether unassailed by him ; "wherever he attacks it he is interesting." The capacity to apply theoretical conceptions to practical uses is illustrated by his applying the discussion of a theorem on the geometrically similar movement of fluid bodies to the problem of steering the balloon.‡ That he still preserves a deep interest in the subject of one of the greatest works of his life is shown by his discovering, quite recently, whilst making experiments on his own eyes, that their fundi were themselves luminous, so that he was able to recognise the movement of his own arm in intense darkness.§ In the autumn of 1887 the German Empire founded a physical-technical institution, Dr. Werner Siemens, the well-known electrician, having given for the purpose a sum of one half-million of marks (£25,000). The institute comprises two departments, one for purely scientific purposes, and the other concerned with the application of scientific physics to technical purposes. The first is a laboratory for the advancement of pure science. Such work as may be necessary for the advancement either of science or of technical pursuits, and which requires for its accomplishment specially fitted rooms, costly apparatus, and special talent is to be done there. The second department

* Lecture on Faraday's anniversary to the Chemical Society in London, on April 5, 1881. ("Lectures," Vol. II., p. 283.)
† Ber. A. Berliner Akad. D. Wiss, 1882.
‡ Ber. D. Berliner Akad. D. Wiss, 1884.
§ "Collected Essays," Vol. I., p. 101.
‖ "Studies on electrical limiting layers." *Wied. Ann.*, Vol. II., p. 337.
¶ "On the internal forces of magnetised and dielectrically polarised bodies." Royal Soc. *Proc.*, XXXVI., 1887.
** Ber. D. Berliner Akad. D. Wiss, 1884.
†† Kronecker's and Weierstrass "Journal of Mathematics," Vol. C., p. 142.

* "Lectures." Vol. II., p. 141.
† "Ber. d. Berl.," Akad de Wiss, 1888, p. 647.
‡ "Collected Essays." Vol. I., p. 158, and Ber. E. Berl. Akad. 1873, p. 501.
§ "A. Koenigs Zeitsur f Psychol u Physiol d." Tinnes Organo. Bd. 1. § 1.

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has for its object to develop technical-scientific methods and appliances, and to keep industry abreast of the progress of science. Over this great and important new institution, v. Helmholtz was chosen by the Government to preside, whilst he was further appointed director of the first, or purely scientific, department. In consequence, he resigned the Chair of Physics and the directorship of the Physical Institute of Berlin, though he still retains the position of Professor ordinarius in the University, and delivers lectures on special subjects of theoretical physics. In 1883 the German Emperor conferred on Herr Helmholtz and on his family the honour of hereditary nobility.

To give an adequate account of the life and works of v. Helmholtz would require a large volume. The brief notice of those works which we have been enabled to give leads us, however, almost naturally to certain more general reflections concerning his genius, character, and life-work.

One of the first reflections which occurs to one in relation to the scientific work of v. Helmholtz is, that no problem has appeared to him impossible, and, at the same time, he has considered no technical detail insignificant or unimportant. His estimate of the value of popular exposition has been a high one, and he has not thought it beneath himself to lecture and write in a popular style. Even the readers of this sketch have had the opportunity of appreciating, from the quotations which it contains, the clear and beautiful manner in which he can explain difficult problems in mathematics, in physical science, or in philosophy. In connection with these popular expositions a reflection must force itself upon everyone, capable of judging, in reference to one of the highest characteristics of v. Helmholtz as a popular teacher: he does not sink to the level of his audience, but he draws them up towards himself.

But in addition to science, the arts, and Nature also, find a place in his great mind. Of music he is a friend full of understanding and devotion. Already in 1857, in the birthplace of Beethoven (Bonn), he praised the power of music in the following words:—"In an artistic musical work the movement of sound follows the outflow of the artist's own emotions. Now gently gliding, now gracefully leaping, now violently stirred, penetrated, and laboriously contending with the natural expression, the stream of sound, in primitive vivacity, bears, even into the hearer's soul, unimagined moods which the artist had overheard from his own, and finally raising him to that repose of everlasting beauty of which God has allowed but a few of his elect favourites to be the heralds." After leading home, as his wife, to his stately official dwelling, the gifted daughter of the celebrated statesman Robert von Mohl, the hospitality of the honoured couple was exercised in the noblest manner. The evening receptions brought together a great number of the most learned and accomplished men and women of Berlin, and were always rendered charming by the musical talents of the most celebrated artists. As admirers of Wagner, they often made a pilgrimage to Bayreuth during the representations there, and thence the great investigator loved to wend his way to the world of Alpine Nature in the Engadine.

Accurate and close as is his mind in the pursuit of scientific truths, his sensitive nature expands at the sight of the higher regions of Nature. In the introduction to his lecture on "Ice and Glaciers" he says "whilst some content themselves with admiring from afar the dazzling adornment which the pure luminous masses of snowy peaks, interposed between the ocean blue of the sky and the softer green of the meadows, lend to the landscape, others more boldly penetrate into the strange world, willingly subjecting themselves to extreme degrees of exertion and danger, if only they may fill themselves with the aspect of its sublimity."

What a noble revelation of his inner self does he afford us in the toast in honour of the town of Heidelberg, which he proposed on the occasion of the fifth centenary of the foundation of the University of Heidelberg.

He would, he said, consider the beauty of the University town from the standpoint of the man of science. "Was it a mere accident that it was from these green hills that the mental eye of man for the first time penetrated the immeasurable world of space with the idea of how the chemical nature of the heavenly bodies might be deciphered—an undertaking which just before must have appeared an utter impossibility? I think the opposite. Something of a poet's intuition the investigator must have. Naturally, he must have care and patience to sift and prepare his material. But work alone cannot compel luminous ideas; these, like Minerva from the head of Jupiter, spring into being unexpected and unforeseen; we know not whence they come. This only is certain. To him who knows life only from books and paper, and who is tired and exhausted by the monotony of work, to him they come not. The consciousness of fulness of life and power must be present, such as comes from wandering in the pure air of the mountains. And when the wanderer, separated by the quiet peacefulness of the forest from the turmoil of the world, beholds, at one glance, spread before him, the rich plain, with the fields and villages, and the setting sun spinning golden threads over the distant hills, then arise in sympathy, in the dark background of his mind, the germs of new ideas, destined to bring light and power into the inner world of his imagination, where before there was chaos and darkness." Thus this great man, in the festive hours, allows us to catch a glimpse of the workings of his mind. But he who would appreciate the full stature of this ruling mind must climb the lower intellectual heights, and the greater the height he is able to attain the more gigantic will the mountain seem above him. To-day the scientific men of both hemispheres unite to do honour to v. Helmholtz. A gold medal has been struck in his honour, which is to be annually awarded to the most worthy of his co-workers. Let the cultured of all classes hand the laurel crown to one of the noblest of men, cherishing the hope that his exalted intellect may long remain to enlighten us.

HUGO KRONECKER.

ELECTRICAL PAPERS AT THE BRITISH ASSOCIATION.

The following is a complete list of the electrical Papers read, and reports presented, at the recent meeting of the British Association:—

SECTION A.

PROFS. W. E. AYRTON, F.R.S., and A. W. RUCKER, F.R.S.—"On the Magnetic Field near the South London Electrical Railway."

J. BROWN.—"On Clausius' Theory of Electrolytic Conduction, and on some recent Evidence for the Dissociation Theory of Electrolysis."

A. P. CHATTOCK.—"On the Electrification of Needle Points in Air."

PROF. A. GRAY.—"Note on the Electro-magnetic Theory of the Rotation of the Plane of Polarised Light."

PROF. D. E. JONES.—"On the Measurement of Stationary Hertzian Oscillations and the Damping of Electric Waves along Wires."

PROF. J. VIRIAMU JONES and T. HARRISON.—"On the Periodic Time of Tuning Forks Maintained in Vibration Electrically."

J. LARMOR.—"The Character of Electrical Radiation, with a Mechanical Analogy."

J. MILNE, F.R.S.—"On Phenomena which might be Observable if the Hypothesis that Earthquakes are Connected with Electrical Phenomena be Entertained."

R. L. MOND.—"Electrolytic Problems."

W. MOON.—"Absolute Units of Measurement."

W. N. SHAW, F.R.S.—"Report on the present State of our Knowledge in Electrolysis and Electro-chemistry."

G. JOHNSTONE STONEY, F.R.S.—"On the Relations between Electrical Units."

PROF. W. STROUD.—"Some Revolutionary Suggestions on the Nomenclature of Electrical and Mechanical Units."

J. SWINBURNE.—"On the Measurement of Liquid Resistance."

J. SWINBURNE.—"The Causes of Variation of Clark Standard Cells."

W. THORP.—"On the Propagation of Electro-magnetic Waves in Wires."

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F. T. TROUTON.—"Magnetic Experiments Made in Connection with the Determination of the Rate of Propagation of Magnetisation in Iron."

A. G. WEBSTER, D.Sc.—"On a Method of Determining the Ratio between the Electrostatic and Electro-magnetic Units."

Report of the Committee on Researches in Electro-optics.

Report of the Committee on Electrolysis.

Report of the Committee on the Phenomena accompanying the Discharge of Electricity from Points.

Report of the Committee on the Reduction of Magnetic Observations.

Report of the Committee on Electrical Standards.

SECTION B.

W. CROOKES, F.R.S.—"Electrical Evaporation of Metals and Alloys."

DR. J. H. GLADSTONE, F.R.S., and W. HIBBERT.—"Some Experiments on the Molecular Refraction of Dissolved Electrolytes."

H. C. JENKINS.—"Note on Electrolysis of Alloys."

PROF. ROBERTS-AUSTEN, F.R.S.—"Certain Pyrometric Measurements and Method of recording them."

SECTION G.

A. R. BENNETT.—"The Telephoning of Great Cities."

A. R. BENNETT.—"Orran Electrical Parcel Exchange System."

G. FORBES.—"Recent Progress in the use of Electric Motors."

W. H. PREECE.—"The London and Paris Telephone."

J. A. TIMMIS.—"Electric Lighting in Trains."

THE MEASUREMENT OF LIQUID RESISTANCES.*

BY J. SWINBURNE.

The great difficulties in measuring liquid resistances arise from polarisation at the electrodes. Various methods of eliminating the errors arising from polarisation, and from variations of surface resistance due to bubbles, have come into use; the most usual being to employ an alternating current and a telephone.

The following are some methods of avoiding polarisation errors in a manner analogous to that employed by Sir William Thomson, Mr. Heaviside, and others, in measuring low resistances. In measuring low resistances, the resistances of the contacts are high in comparison, and have to be eliminated. Fig. 1 shows the vessel employed. It consists of a glass tube, with cups, A and B, at the ends, for the main electrodes. Near the ends are feeler cups, C, D, and it is the difference of potential of these feeler cups that is measured. They are connected by means of parchmented siphon tubes, such as those used in Raoult's cell, with vessels containing electrodes in a suitable electrolyte. For instance, suppose the resistance of sulphuric

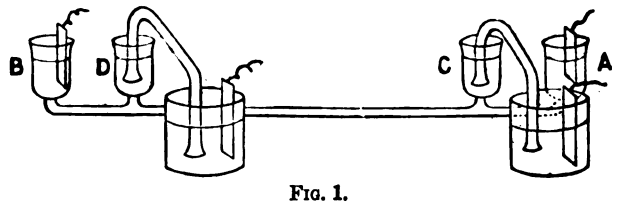

FIG. 1.

acid is to be measured. The main electrodes are platinum or lead. The siphon tubes are filled with acid and connected to vessels filled with sulphate of zinc. The electrodes in these are zinc amalgam. The apparatus may be arranged either so that there is no current from C to D, or so that there is a current which may polarise the amalgams a little. In this case the polarisation can be observed. Fig. 2 shows a method with no current. The main circuit from the battery, E, is through a resistance, R, which is fairly large, so that variations of resistance or back pressure elsewhere in the circuit do not affect the current much. Then it passes through a standard resistance, S, to the main electrode, then through the tube back to the battery. The fall of pressure between the feelers, C and D, is compared with that over the standard resistance, S, by means of the potentiometer arrangement shown diagrammatically. For accurate work a resistance box is used; the wire is only shown for clearness. In this case there is no current in the feeler circuit, and, therefore, no polarisation. A deflection can be taken on each side of zero, if desired, so as actually to reverse the current. Polarisation of the feeler electrodes can also be detected instantly by breaking both the cell circuits. There should then be no deflection. The drawback to this method is that successive readings have to be taken, and if bubbles are coming off the main electrodes, the main current can never be quite constant. Fig. 3 shows another

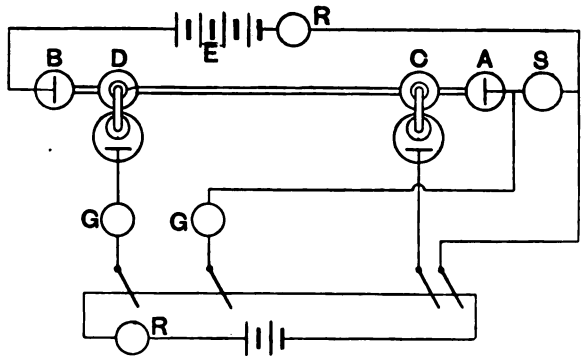

FIG. 2.

disposition with a differential galvanometer, whose coils are lettered G G. In this case there is a current in the feeler circuit. To make sure that it produces no error the direction of the main current is commuted quickly at K. Any polarisation then gives a double deflection. The apparatus may also be coupled up as a Thomson low-resistance bridge. By varying the number of cells, Ohm's law can be checked. As Prof. Stroud has pointed out to me, the resistances of the siphon tubes must be taken into account. They can, however, be made inappreciable in comparison with that of the galvanometer circuits.

Amalgamated zinc does polarise slightly, or some other action takes place which produces an equivalent result. Unless the

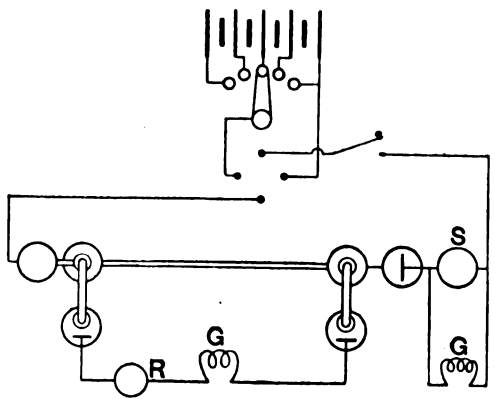

FIG. 3.

time of contact is long, however, it does not give rise to trouble. Polarisation shows at once by the deflection on lifting the main key.

The main tube is calibrated by filling it with mercury. Mine is straight, but it would be better to coil it up to go into a water bath easily. If one siphon tube is not enough a second intermediate tube with a vessel can be used. I think one is generally enough, however. For instance, for measuring caustic sulphate of soda would be used in the siphon tubes, and so on. I have not experimented on various electrodes yet. Amalgams of silver or copper in suitable solutions, or mercury in mercurous nitrate, may be better than zinc amalgam in zinc sulphate.

* Paper read before the British Association, in Section A, at Cardiff, August, 1891.

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ELECTROLYTIC PROBLEMS.*

BY ROBERT L. MOND.

The study of Clerk Maxwell's theory of the propagation of electric energy through the dielectric along conductors, having, through the magnificent experimental work of Hertz, emerged from the purely mathematical stage, it may be of interest to apply it to the elucidation of the phenomena occurring on the propagation of electric energy through that class of conductors known as electrolytes.

The propagation of electric energy along metallic conductors is invariably found to produce the following four phenomena: —I.—The electric energy is propagated with the velocity of light. II.—An electro-magnetic field is produced. III.—Induced currents are produced in neighbouring conductors. IV. —Heat is produced in the conductor uniformly along its length proportional to the strength of the current and the resistance of the conductor.

These four phenomena are also produced during electrolysis; they are, however, accompanied by a fifth phenomenon, namely, chemical decomposition at the electrodes, and this chemical decomposition is strictly proportional to the strength of the current, but not to its intensity. Hence, by infinitely increasing the potential and diminishing the strength of the current, we can make the absorption of electrical energy due to chemical action as small as we please; and thus we can establish so complete an analogy between propagation of electric energy along metallic conductors and along electrolytes that any views brought forward to explain the phenomena in the one case must perforce apply to the other.

The theory of the propagation of electric energy along metals has been thus concisely defined by Prof. J. J. Thomson:— "The velocity of transmission of an electric impulse along a wire is, according to Maxwell's theory, equal to the velocity with which light passes through the dielectric in which the energy resides, and the function of the wire seems merely to be that of guiding the discharge which travels at a rate fixed by the dielectric." Prof. H. Hertz has recently shown that when an electric oscillation travels along a wire the electric force produces a mechanical effect at right angles to the wire, whilst the magnetic force which accompanies it tends to repel a ring brought into its vicinity; thus there are two vibrations perpendicular to each other, the nodes of the one coinciding with the antinodes of the other, passing along the wires, whence he concludes that "from the above experiments with conductors of very simple form it is evident that a conductor of any form, when placed in the path of electro-magnetic waves, is subject to forces of a very complex character."

Since a guiding conductor surrounded by dielectric is required (according to the above theory) for the propagation of electric energy in definite directions, the question arises, "How can an electrolyte act as such a guiding conductor?" For this there are two possible explanations. Either (1) the bulk of the electrolyte might be considered the conductor, and the surrounding medium the dielectric, such as glass or air; or (2) in the electrolyte itself a rearrangement of molecules is produced, some (*i.e.*, the best conducting) forming the guiding conductors along the lines of force between the electrodes, others dielectric tubes surrounding the same. The first proposition is untenable, for, although it explains how an electro-magnetic field may be produced outside the electrolyte, it utterly fails to explain how a fairly uniform field is produced inside it. Molecular chains have formed the basis of every theory of electrolysis since they were first proposed by Grotthuss, although the mode of action of the molecules has been explained in a great number of different ways. The molecular arrangement required for the second proposition, *i.e.*, molecular chains surrounded by dielectric tubes, was first proposed by Prof. G. Wiedemann, who brings weighty proofs in its favour, but who also, like his predecessors, assumes that the current passes through the molecular chain. He has, however, provided the requisite mechanism for the application of Clerk Maxwell's theory to electrolysis.

The electric energy in being propagated through these dielectric tubes along the chain of conducting molecules produces these magnetic and electric effects which act chemically on the dielectric, decomposing the molecules into atoms, or weakening their affinity along the zones of intense electric action surrounding each molecular chain. A similar view was already suggested by Faraday, when he considers the electric current to be "an axis of power having contrary forces exactly equal in amount in opposite directions," modifying the chemical affinity of the electrolyte in directions parallel to the axis, and providing the conditions for the transfer of electro-positive and negative ions in their respective directions. That there is a tendency for a strong electric field to produce molecular decomposition is evident from the action of the silent discharge and the electric arc, and also from such observations as those made by Bouty of electrolytic action on the surface of condenser plates.

The view proposed, which considers metallic and electrolytic conduction as identical, finds strong support in the following investigations. Prof. J. J. Thomson finds, as the result of experiments, "that the velocity of propagation of a rapidly alternating current along an electrolyte surrounded by air cannot differ much from the rate along a wire;" and in examining the resistance of electrolytic alternating currents, "the results obtained agree sufficiently well to enable us to say that the relative resistance of electrolytes is the same when a current is alternating a hundred million times a second, as for a steady current." Prof. Mengarini, of Rome, in a very exhaustive Paper on electrolysis by alternating currents, formulates the following law:—(4) "A limiting value to the rapidity of alternations exists, beyond which decomposition does not take place;" which he proves both theoretically and experimentally; and he finds that at the limit "the voltameter only becomes heated by the passage of the current like an ordinary metallic conductor." He also states in his conclusions (6): "A voltameter traversed by an alternating current behaves like a metallic conductor possessing self-induction." A Committee appointed by the British Association has also investigated a series of solid compounds, such as sulphides and selenides, some of which conduct purely metallically, others purely electrolytically, and others in both ways at the same time, and declared themselves unable to draw any marked line of distinction between these bodies.

To resume. The number of the molecular chains formed will depend on the strength of the electric field and on the concentration of the electrolyte, whilst the cross-sectional area of each zone of decomposition will depend on the strength of the current and number of chains, and the current density will be measured by the number of such chains in the cross-section of the electrolyte.

The existence of these zones explains:—

I.—How the atoms can travel along molecular chains towards their respective electrodes without recombination.

II.—Why the atoms are given off as molecules at the electrodes only, because there the electric field being weakest, and atoms of one kind preponderating, they combine and are given off.

By artificially weakening the electric field by introducing a metallic plate into the path of the molecular chains, such plate acts similar to an electrode. Mr. A. Tribe, by interposing silver plates in a copper sulphate cell, obtained one end coated with copper, the other with protoxide of silver, and found the boundary line of the zone of deposition to be at right angles to the line of flow of the current. This enabled him to observe the refraction of this line of flow by interposing a porous vessel with water, whose parallel sides were inclined at an angle of 45deg. to the sides of the rectangular electrolytic trough, a most important verification of the directive tendency of the current in an electrolyte.

Prof. J. J. Thomson has also shown that an electric field is weakened in the presence of a solid dielectric, because the surface tension is increased. Hence, if a solid dielectric is intruded into a zone of intense electric action, by sending the current through a porous diaphragm or a cracked glass plate, the fields will be weakened and atoms liberated, as abundantly proved by the experiments of Grotthuss, F. Braun, Ostwald, Tamman, Overbeck, and others.

* Paper read before the British Association, in Section A, at Cardiff, August, 1891.

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III.—Why the atoms cannot escape through out of the liquid is explained by the directive force preventing the atoms escaping laterally out of the decomposing zones

It is obvious that only an exceedingly small electromotive force would be required to produce the minimum zone of decomposition necessary for electrolysis along a single or few molecular chains; and, since a weak electric field could only have a few lines of force, there would only be a few such rows, and this gives us an explanation for the electrolysis produced by the infinitesimal currents observed by Helmholtz, M. Depretz, and others. Also, if two bad conductors of slightly varying conductivity be mixed, such as alcohol and water, the conditions are provided for electrolytic action, the better conducting forming the guiding conductors, the other dielectric tubes, whence a greatly increased conducting power is produced and observed; as witness the experiments of Gladstone and Tribe, Overbeck, Pouillet, Ayrton and Perry, and others. This also explains the action of exceedingly minute quantities of impurities on influencing the conductivity of electrolytes.

The assumption that the solvent is primarily decomposed suffices to explain all the chemical phenomena observed in electrolytic cells, and was fully accepted by the older electricians, being specially worked out by Berzelius and his school. The electrolysis of solutions by strong currents gives strong support to this view; for when constituents of the solvents are more rapidly generated than they can be absorbed by secondary chemical action, they are given off in the free state. I have shown this to be the case for copper sulphate solutions, from which I have obtained oxygen and hydrogen by sufficlently increasing the strength of the current. Kohlrausch also states that in very dilute solutions water is discomposed.

The complicated phenomena classed under polarisation are mainly due to voltaic currents arising from chemical changes taking place at the electrodes and their physical effects.

The phenomenon known as wandering of the Ions has been shown by Professors Wiedemann and Quincke to be due to three causes. I. The free charges on the surface of the molecular chains, producing motion in opposite directions of the salt and the solvent molecules. II. The same effect being also produced by the free charges on the electrodes; and III. By the electrification of the vessel containing the electrolyte, which latter they also consider to explain the phenomena known as electrical endosmose.

It is obvious that these explanations may also be adopted in connection with the above expressed views.

In order to corroborate the theory of molecular chains, I have carried out a series of experiments with different apparatus to study whether the displacement of the molecular conductors would influence the conductivity. I found that the resistance of a jet of electrolyte, which was caused to flow at varying speeds between the electrodes rose proportional to the velocity of the electrolyte up to a maximum of about 10 per cent. of the total deflection. In order to ensure the result being solely due to the velocity of the jet and not to diminution of the area of the conductor, the electrodes carefully insulated except at places where the jets (one to each electrode) impinged, were kept immersed in separate cells connected with a tube and provided with overflow tubes, the jet playing beneath the surface of the electrolyte; the result was in complete accordance with those previously obtained.

Faraday has shown that an interrupted current flowing through an electro-magnet is able to induce a current in a secondary coil made of an india-rubber tube filled with an electrolyte wound round the keeper. Considering it to be of interest to have both a primary and secondary coil of electrolytic conductor, I constructed two flat spirals of india-rubber tubing, filled with acidulated copper sulphate, and provided with copper electrodes; for the primary, a continuous current of 90 volts was employed, which was simply interrupted by means of an electric bell worked from an independent battery. The secondary coil was connected with a Sir Wm. Thomson 60 ohm reflecting galvanometer; a thermo current giving 10 divisions was observed, but the effect of the induced alternating current was to produce intermittently deflections of over 50 divisions on each side of the zero, thus removing all doubt of the success of the experiment.

The complete analogy between an electrolyte and a high-resistance wire led me to suspect that if such a wire were inserted between the electrodes electrolysis would be observed at the ends. On referring to the literature, I found that Jacobi had obtained the desired result with a German silver wire in a copper sulphate solution, but did not obtain the result with platinum. Having some thin platinoid wire at hand, I determined to repeat the experiment, coiling the wire to increase its resistance. Copper was deposited along about one-half of it, beginning slowly at the negative electrode, whilst the other half turned black by oxydation, and was gradually destroyed at the end nearest the positive electrode.

I know that the view I have ventured to bring before you leaves many facts connected with electrolysis as yet unexplained, but the same must be admitted for all other theories on the subject hitherto propounded, over which this view has, I believe, the advantage that it brings the propagation of electric energy along electrolytes into harmony with the now generally accepted theory of Clerk Maxwell of the propagation along metallic conductors, and that it offers an explanation of the electrical as well of the chemical phenomena observed.

DR. OLIVER LODGE'S PRESIDENTIAL ADDRESS TO SECTION A.

(ABSTRACT.)

During the past year three or four events call for special mention in an annual deliverance of this kind by a physicist. One is the Faraday centenary, which was kept in a happy and simple manner by a cosmopolitan gathering in the place so long associated with his work, and by discourses calling attention to the modern development of discoveries made by him. Another is the decease of the veteran Wilhelm Weber, one of the originators of that absolute system of measurement which, though still ungrasped in its simplicity and completeness by the majority of men engaged in practice, nor even, I fear, wholly understood by some of those engaged in University teaching, has yet done so much, and is destined to do still more, for the unification of physical science, and for a thorough comprehension of its range and its limitations. A third event of importance during the year is the discovery in America of a binary system of stars, revolving round each other with grotesque haste, and with a proximity to each other such as to render their ordinary optical separation quite impossible. The change in the refrangibility of light by reason of the motion of its source, though commonplace enough now, was at first regarded as too small to be observed, and one or two attempts directed to detecting the effect of this principle on the spectra of the stars, or sometimes on sunlight reflected by a 45deg. mirror into the line of the earth's motion (which is not a possible method), wholly failed. I take pleasure in remembering that this effect was clearly observed for the first time by the gentleman we this year honour as our President; and that it is by this very means that the latest sensational discovery in astronomy of the rapidly revolving twin star, β-Aurigæ, by Prof. Pickering and the staff connected with the Draper Memorial, was made. The fourth event to which it behoves me to refer is the practical discovery of a physical method for colour photography. The first suggestion of the method, so far as I know, was made by Lord Rayleigh in the course of a mathematical paper on the reflection of light, and with reference to some results of Becquerel obtained on a totally different plan. He said in a note that if by normal reflection waves of light were converted into stationary waves, they could shake out silver in strata half a wave-length apart, and that such strata would give selective reflection and show iridescence. Independently of all this, Herr Otto Wiener, imitating Hertz's experiments with ordinary light, in 1889, reflected a beam directly back on itself, and, by interposing a very thin collodion film at extraordinarily oblique incidence, succeeded in the difficult experiment of so magnifying, by the cosine of inclination, the half wave-length, as to get the silver deposited in strata of visible width, and thus to photograph the interference nodes themselves at the places where they were cut by the plane of the film. Then M. Lippmann, using a thicker film, not put obliquely but normal to the light, obtained the strata within the thickness of the film itself—hundreds of layers; and so, employing incident light of definite wave-length, was able to produce a stratified deposit, which reflected back at appropriate incidences the same wave-length as produced it; thus reproducing, of course, the definite colour.

I now leave the retrospect of what has been done, although many other topics might usefully detain us, and I proceed to glance forward at the progress ahead and at the means we have for effectively grappling with our due share of it. There is a subject which has

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long been in my mind, and which I determined to bring forward whenever I had a cathedral opportunity of doing so; and, now, if ever, is a suitable occasion. It is to call attention to the fact that the further progress of physical science in the somewhat haphazard and amateur fashion in which it has been hitherto pursued in this country is becoming increasingly difficult, and that the quantitative portion especially should be undertaken in a permanent and publicly-supported physical laboratory on a large scale. If such an establishment were to weaken the sinews of private enterprise and individual research it should be strenuously opposed; but, in my opinion, it would have the opposite effect, by relieving the private worker of much which he can only with great difficulty, sacrifice, and expense, undertake. To illustrate more precisely what I mean, it is sufficient to recall the case of astronomy. The amateur astronomer has much work lying ready to his hand, and he grapples with it manfully. To him is left the striking out of new lines and the guerilla warfare of science. Skirmishing and brilliant cavalry evolutions are his natural field; he should not be called upon to take part in the general infantry advance. It is wasting his energies, and he could not do it in the long run well. What, for instance, would have been the state of astronometry—the nautical almanack department of astronomy—without the consecutive and systematic work of the National Observatory at Greenwich? It may be that some enthusiastic amateurs would have devoted their lives to this routine kind of work; and here at one time, and there at another, a series of accurate observations would have been kept for several years. Pursued in that way, however, not only would the effort be spasmodic and temporary, but the energy and enthusiam of those amateurs would have been diverted from the pioneering more suited to them, and have been cramped in the groove of routine, eminently adapted to a permanent official staff, but not wholesome for an individual. Long-continued consecutive observations may be made by a leader of science, as functions may be tabulated by an eminent mathematician; but if the work can be done almost equally well (some would say better) by a professional observer or computator, how great an economy results.

Now all this applies equally to physics. The ohm has been determined with 4-figure, perhaps with 5-figure accuracy; but think of the list of eminent men to whose severe personal labour we owe this result, and ask if the spoil is worth the cost. Perhaps, in this case, it is, as a specimen of well-conducted determination. We must have a few specimens, and our leaders must show us the way to do things. But let us not continue to use them for such purposes much longer. The quest of the fifth or sixth decimal is a very legitimate, and may become a very absorbing, quest, but there are plenty of the rank and file who can undertake it if properly generalled and led: not as isolated individuals, but as workers in a National Laboratory under a competent head and a governing committee. By this means work far greater in quantity, and, in the long-run, more exact in quality, can be turned out, by patient and conscientious labour without much genius, by the gradual improvement of instrumental means, by the skill acquired by practice, and by the steady drudgery of routine. Paris has long had one form of such an institution, in the Conservatoire des Arts et Métiers, and has been able to impose the metric system on the civilised world in consequence. It can also point to the classical determinations of Regnault as the fruits of just such a system. Berlin is now starting a similar or a more ambitious scheme for a permanent national physical institute. Is it not time that England, who in physical science, I venture to think, may in some sort claim a leading place, should be thinking of starting the same movement?

The Meteorological and Magnetic Observatory at Kew (in the inauguration of which this Association took so large a part) is a step, and much useful quantitative work is done there. The new Electric Standardising Laboratory of the Board of Trade is another and, in some respects perhaps, a still closer approximation to the kind of thing I advocate. But what I want to see is a much larger establishment, erected on the most suitable site, limited by no speciality of aim nor by the demands of the commercial world, furnished with all appropriate appliances, to be amended and added to as time goes on and experience grows, and invested with all the dignity and permanence of a national institution; a Physical Observatory, in fact, precisely comparable to the Greenwich Observatory, and aiming at the very highest quantitative work in all departments of physical science. That the arts would be benefited may be assumed without proof. It is largely the necessity of engineers that has inspired the amount of accuracy in electrical matters already attained. The work and appliances of the mechanical engineer eclipse the present achievements of the physicist in point of accuracy, and it is by the aid of the mechanician and optician that precision even in astronomy has reached so high a stage. There is no reason why physical determinations should be conducted in an amateur fashion, with comparatively imperfect instruments, as at present they mostly are. Discoveries lie along the path of extreme accuracy, and they will turn up in the most unexpected way. The aberration of light would not have been discovered had not Bradley been able to measure to less than 1 part in 10,000; and what a brilliant and momentous discovery it was! He was aiming at the detection of stellar parallax, but the finite velocity of light was a bigger discovery of light than any parallax. This is the type of result which sometimes lurks in the fifth decimal, and which confers upon it an importance beside which the demands of men who wish to serve the taste and the pocket of the British public sink into insignificance.

In a National Observatory accuracy should be the one great end: the utmost accuracy in every determination that is decided on and made. Only one thing should be more thought of than the fifth significant figure, and that is the sixth. The consequences flowing from the results may safely be left; such as are not obvious at once will distil themselves out in time. And the great army of outside physicists, assured of the good work being done at headquarters, will (to speak again in astronomical parable) cease from peddling with taking transits or altitudes, and will be free to discover comets, to invent the spectroscope, to watch solar phenomena, to chemically analyse the stars, to devise celestial photography, and to elaborate still more celestial theories, all of which novelties in their maturity may be handed over to the National Observatory, to be henceforth incorporated with, and made part of, its routine life, leaving the advance guard and skirmishers free to explore fresh territory, secure in the knowledge that what they have acquired will be properly surveyed, mapped, and utilised, without further attention from them. As to the practical applications, they may in any case be left to take care of themselves. The instinct of humanity in this direction, and the so-called solid gains associated with practical achievements, will always secure a sufficient number of acute and energetic workers to turn the new territory into arable land and pasture adapted to the demands of the average man. The labour of the agriculturist in rendering soil fertile is, of course, beyond praise; but it is not the work of the pioneer. As Mr. Huxley eloquently put it, when contrasting the application of science with the advance of science itself, speaking of the things of commercial value which the physical philosopher sometimes discovers:—"Great is the rejoicing of those who are benefited thereby, and, for the moment, science is the Diana of all the craftsmen. But even while the cries of jubilation resound, and this flotsam and jetsam of the tide of investigation is being turned into the wages of workmen and the wealth of capitalists, the crest of the wave of scientific investigation is far away on its course over the illimitable ocean of the unknown."

I have spoken of the work of the National Laboratory as devoted to accuracy. It is hardly necessary to say that it will be also the natural custodian of our standards, in a state fit for use and for comparison with copies sent to be certified. Else, perhaps, some day our standard ohm may be buried in a brick wall at Westminster, and no one living may be able to recall precisely where it is.

But, in addition to these main functions, there is another, equally important with them, to which I must briefly refer. There are many experiments which cannot possibly be conducted by an individual, because 40 and 50 years is not long enough for them. Secular experiments on the properties of materials—the elasticity of metals, for instance; the effect of time on molecular arrangement; the influence of long exposure to light, or to heat, or to mechanical vibration, or to other physical agents. Does the permeability of soft iron decay with age, by reason of its Ampèrian currents? Do gases cool themselves when adiabatically preserved, by reason of imperfect elasticity or too many degrees of freedom of their molecules? Unlikely, but not impossible. Do thermoelectric properties alter with time? And a multitude of other experiments which appear specially applicable to substanees in the solid state—a state whieh is more complicated, and has been less investigated, than either the liquid or the gaseous; a state in which time and past history play an important part.

Whichever of these long researches requires to be entered on, a national laboratory, with permanent traditions and a continuous life, is undoubtedly the only appropriate place. At such a place as Glasgow the exceptional magnitude of a present occupant may, indeed, inspire sufficient piety in a successor to secure the continuance of what has been there begun; but in most college laboratories, under conditions of migration, interregnum, and a new *régime*, continuity of investigation is hopeless.

I have, at any rate, said enough to indicate the kind of work for which the establishment of a well-furnished laboratory with fully-equipped staff is desirable, and I do not think that we, as a nation, shall be taking our proper share of the highest scientific work of the world until such an institution is started on its career. There is only one evil which, so far as I can see, is to be feared from it: if ever it were allowed to impose on outside workers as a central authority, from which infallible dicta were issued, it would be an evil so great that no amount of good work carried on by it could be pleaded as sufficient mitigation. If ever by evil chance such an attitude were attempted, it must rest with the workers of the future to see that they permit no such shackles; for if they are not competent to be independent, and to contemn the voice of authority speaking as mere authority, if their only safeguard lies in the

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absence of necessity for struggle and effort, they cannot long hope to escape from the futility which surely awaits them in other directions.

I am thus led to take a wider range, and, leaving temporary and special considerations, to speak of a topic which is as yet beyond the pale of scientific orthodoxy, and which I might, more wisely, leave lying by the roadside.

Our ancestors fought hard and suffered much for the privilege of free and open inquiry, for the right of conducting investigation untrammelled by prejudice and foregone conclusions, and they were ready to examine into any phenomenon which presented itself. This attitude of mind is, perhaps, necessarily less prominent now, but it would be a great pity if a too absorbed attention to what has already been acquired, and to the fringe of territory lying immediately adjacent thereto, were to end in our losing the power of raising our eyes and receiving evidence of a totally fresh kind, of perceiving the existence of regions into which the same processes of inquiry as had proved so fruitful might be extended, with results at present incalculable and perhaps wholly unexpected. I myself think that the ordinary processes of observation and experiment are establishing the existence of such a region ; that, in fact, they have already established the truth of some phenomena not at present contemplated by science, and to which the orthodox man shuts his ears.

Everybody is by no means bound to investigate everything ; though, indeed, it is customary in most fields of knowledge for those who have kept aloof from a particular inquiry to defer in moderation to those who have conducted it, without feeling themselves called upon to express an opinion. Some there are, no doubt, who consider that they have given sufficient time and attention to the subject with only negative results. Their evidence is, of course, important ; but, plainly, negative evidence should be of immense bulk and weight before it can outweigh even a moderate amount of positive evidence. However, it is not of the action of individuals that I wish to speak, it is of the attitude to be adopted by scientific bodies in their corporate capacity ; and for a corporate body of men of science, inheritors of the hard-won tradition of free and fearless inquiry into the facts of Nature untrammelled by prejudice, for any such body to decline to receive evidence laboriously attained and discreetly and inoffensively presented by observers of accepted competency in other branches, would be, if ever actually done and persisted in, a terrible throwing away of their prerogative, and an imitation of the errors of a school of thought against which the struggle was at one time severe.

Now let me be more definite, and try to state what this field is, the exploration of which is regarded as so dangerous. I might call it the borderland of physics and psychology. I might call it the connection between life and energy ; or the connection between mind and matter. It is an intermediate region, bounded on the north by psychology, on the south by physics, on the east by physiology, and on the west by pathology and medicine. An occasional psychologist has groped down into it and become a metaphysician. An occasional physicist has wandered up into it and lost his base, to the horror of his quondam brethren. Biologists mostly look at it askance, or deny its existence. A few medical practitioners, after long maintenance of a similar attitude, have begun to annex a portion of its western frontier. The whole region seems to be inhabited mainly by savages, many of them, so far as we can judge from a distance, given to gross superstition. It may, for all I know, have been hastily traversed and rudely surveyed by a few clear-eyed travellers ; but their legends concerning it are not very credible, certainly are not believed. Why not leave it to the metaphysicians ? I say it has been left to them long enough. They have explored it with insufficient equipment. The physical knowledge of the great philosophers has been necessarily scanty. Men of genius they were, and their writings may, when interpreted, mean much. But to us, as physicists, they are unsatisfactory ; their methods are not our methods. They may be said to have floated a balloon over the region with a looking-glass attached, in which they have caught queer and fragmentary glimpses. They may have seen more than we give them credit for, but they appear to have guessed far more than they saw. Our method is different. We prefer to creep slowly from our base of physical knowledge, to engineer carefully as we go, establishing forts, making roads, and thoroughly exploring the country ; making a progress very slow, but very lasting. The psychologists from their side may meet us. I hope they will ; but one or other of us ought to begin.

A vulnerable spot on our side seems to be the connection between life and energy. The conservation of energy has been so long established as to have become a commonplace. The relation of life to energy is not understood. Life is not energy, and the death of an animal affects the amount of energy no whit ; yet a live animal exerts control over energy which a dead one cannot. Life is a guiding or directing principle, disturbing to the physical world, but not yet given a place in the scheme of physics. The transfer of energy is accounted for by the performance of work ; the guidance of energy needs no work, but demands force only. What is force ? and how can living beings exert it in the way they do ? By what means is force exerted, and what, definitely, is force ? I can hardly put the question here and now so as to be intelligible, except to those who have approached and thought over the same difficulties ; but I venture to say that there is here something not provided for in the orthodox scheme of physics ; that modern physics is not complete, and that a line of possible advance lies in this direction. But the whole region is unexplored territory, and it is conceivable that matter may react on mind in a way we can at present only dimly imagine. In fact, the barrier between the two may gradually melt away, as so many other barriers have done, and we may end in a wider perception of the unity of nature, such as philosophers have already dreamt of. I care not what the end may be. I do care that the inquiry shall be conducted by us, and that we shall be free from the disgrace of jogging along accustomed roads, leaving to outsiders the work, the ridicule, and the gratification, of unfolding a new region to unwilling eyes.

It may be held that such investigations are not physical and do not concern us. We cannot tell without trying. In that I trust my instinct. I believe there is something in this region which does concern us as physicists. It may concern other sciences too. It must, one would suppose, some day concern biology ; but with that I have nothing to do. Biologists have their region, we have ours, and there is no need for us to hang back from an investigation because they do. Our own science, of Physics or Natural Philosophy in its widest sense, is the King of the Sciences, and it is for us to lead, not to follow. Now I say that the doctrine of ultimate intelligibility should be pressed into other departments also. At present we hang back from whole regions of inquiry and say they are not for us. A few we are beginning to grapple with. The nature of disease is yielding to scrutiny with fruitful result ; the mental aberrations and abnormalities of hypnotism, duplex personality, and allied phenomena, are now at last being taken under the wing of science, after long ridicule and contempt. The phenomenon of crime, the scientific meaning and justification of altruism, and other matters relating to life and conduct, are beginning, or perhaps are barely yet beginning, to show a vulnerable front over which the forces of science may pour. What we know is as nothing to that which remains to be known. This is sometimes said as a truism ; sometimes it is half doubted. To me it seems the most literal truth, and that if we narrow our view to already half-conquered territory only, we shall be false to the men who won our freedom, and treasonable to the highest claims of science.

I must now return to the work of this section, from which I have apparently wandered rather far afield, further than is customary—perhaps further than is desirable. But I hold that occasionally a wide outlook is wholesome, and that without such occasional survey, the rigid attention to detail and minute scrutiny of every little fact, which are so entirely admirable and are so rightly here fostered, are apt to become unhealthy, dull, and monotonous. Our life-work is connected with the rigid framework of facts, the skeleton or outline map of the universe ; and, though it is well for us occasionally to remember that the texture and colour and beauty which we habitually ignore are not therefore in the slightest degree non-existent, yet it is safest speedily to return to our base and continue the slow and laborious march with which we are familiar and which experience has justified. It is because I imagine that such systematic advance is now beginning to be possible in a fresh and unexpected direction that I have attempted to direct your attention to a subject which, if my prognostications are correct, may turn out to be one of special and peculiar interest to humanity.

THE LONDON-PARIS TELEPHONE.*

BY W. H. PREECE, F.R.S.

1. I have already on two occasions, at Newcastle and at Leeds, brought this subject before Section G, and have given the details of the length and construction of the proposed circuit. I have now to report not only that the line has been constructed and opened to the public, but that its success, telephonic and commercial, has exceeded the most sanguine anticipations. Speech has been maintained with perfect clearness and accuracy. The line has proved to be much better than it ought to have been, and the purpose of this Paper is to show the reason why.

The lengths of the different sections of the circuit are as follows:—

London to St. Margaret's Bay	84·5	miles.
St. Margaret's Bay to Sangatte (cable)	23·	,,
Sangatte to Paris	199·	,,
Paris underground	4·8	,,
Total	311·3	,,

* Paper read before the British Association, in Section G, at Cardiff, August, 1891.

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The resistances are as follows :—

Paris underground	70	ohms.
French line	294	„
Cable	143	„
English line	183	„
Total (R)	693	

The capacities are as follows :—

Paris underground	0·43	microfarads.
French line	3·33	„
Cable	5·52	„
English line	1·32	„
Total (K)	10·62	„

$693 \times 10{\cdot}62 = 7{,}359 = K\,R.$

A product which indicates that speeds should be very great.

2. *Trials of Apparatus.*—The preliminary trials were made during the month of March between the chief telegraph offices of the two capitals, and the following microphone transmitters were compared :—

Ader	Pencil form.
Berliner	Granular „ (Hunnings).
D'Arsonval	Pencil „
De Jongh	„ „
Gower-Bell	„ „
Post Office switch instrument	Granules and lamp filaments.
Roulez	Lamp filaments.
Turnbull	Pencil form.
Western Electric	Granular.

The receivers consisted of the latest form of double-pole Bell telephones with some Ader and D'Arsonval receivers for comparison. After repeated trials it was finally decided that the Ader, D'Arsonval, Gower-Bell (with double-pole receivers instead of tubes), Roulez and Western Electric were the best, and were approximately equal.

These instruments were, therefore, selected for the further experiments, which consisted of using local extensions in Paris and London. The wires were in the first instance extended at the Paris end to the Observatory through an exchange at the Avenue des Gobelines. The length of this local line is 7 kilometres. The wires are gutta-percha covered, placed underground, and not suitable for giving the best results.

The results were, however, fairly satisfactory. The wires were extended to the Treasury in London by means of the ordinary underground system. The distance is about two miles, and although the volume of sound and clearness of articulation were perceptibly reduced by these additions to the circuit, conversation was quite practicable.

Further trials were also made from the Avenue des Gobelines on underground wires of five kilometres long, and also with some renters in Paris with fairly satisfactory results. The selected telephones were equally efficient in all cases, which proves that to maintain easy conversation when the trunk wires are extended to local points it is only necessary that the local lines shall be of a standard not lower than that of the trunk line. The experiments also confirm the conclusion that long distance speaking is solely a question of the circuit and its environments, and not one of apparatus. The instruments finally selected for actual work were Gower-Bell for London and Roulez for Paris.

3. The results are certainly most satisfactory. There is no circuit in or out of London on which speech is more perfect than it is between London and Paris. In fact, it is better than I anticipated, and better than calculation led me to expect. Speech has been possible not only to Paris but through Paris to Bruxelles, and even, with difficulty, through Paris to Marseilles, a distance of over 900 miles. The wires between Paris and Marseilles are massive copper wires specially erected for telephone business between those important places.

4. *Business Done.*—The charge for a conversation between London and Paris is 8s. for three minutes' complete use of the wire. The demand for the wire is very considerable. The average number of talks per day, exclusive of Sunday, is 86. The maximum has been 108. We have had as many calls as 19 per hour—the average is 15 during the busy hours of the day. As an instance of what can be done, 150 words per minute have been dictated in Paris and transcribed in London by shorthand writing. Thus in three minutes 450 words were recorded, which at 8s. cost five words for a penny.

5. *Difficulties.*—The difficulties met with in long distance speaking are several, and they may be divided into (*a*) those due to external disturbances and (*b*) those due to internal opposition.

(*a.*) Every current rising and falling in the neighbourhood of a telephone line within a region, say, of 100 yards, whether the wire conveying it be underground or overground, induces in the telephone circuit another current, producing in the telephone a sound which disturbs speech, and if the neighbouring wires are numerous and busy, as they are on our roads and railways, these sounds become confusing, noisy, and ultimately entirely preventative of speech. This disturbance is, however, completely removed by forming the telephone circuit of two wires placed as near to each other as possible, and twisted around each other without touching, so as to maintain the mean average distance of each wire from surrounding conductors, the same everywhere. Thus similar currents are induced in each of the two wires, but being opposite in direction, as far as the circuit is concerned, they neutralise each other, and the circuit, therefore, becomes quite silent.

In England we make the two wires revolve completely round each other in every *four* poles, but in France it is done in every *six* poles. The reason for the change is the fact that in the English plan the actual crossing of the wires takes place in the span between the poles, while in the French plan it takes place at the poles. This is supposed to reduce the liability of the wires to be thrown into contact with each other by the wind, but, on the other hand, it diminishes the geometrical symmetry of the wires—so very essential to ensure silence. As a matter of fact, contacts do not occur on well-constructed lines, and I think our English wires, being more symmetrical, are freer from external disturbance than those in France.

(*b.*) The internal opposition arises from the resistance R, the capacity K, and the electro-magnetic inertia, L, of the circuit. A current of electricity takes time to rise to its maximum strength and time to fall back again to zero. Every circuit has what is called its *time constant*, *t* (Fig. 1), which regulates the number of current waves which can be transmitted through it per second. This is the time the current takes to rise from zero to its working maximum and the time it takes to fall from this maximum to zero again, shown by the shaded portions of the figure, the duration of the working current being immaterial and shown by the unshaded portion. The most rapid form of quick telegraphy requires about 150 currents per second, currents each of which must rise and fall in $\frac{1}{150}$th of a second, but for ordinary telephone speaking we must have about 1,500 currents per second, or the time which each current rises from zero to its maximum intensity must not exceed $\frac{1}{3000}$th part of a second. The time constant of a telephone circuit should, therefore, not be less than ·0003 second.

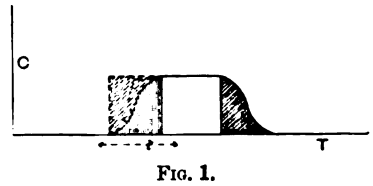

FIG. 1.

Resistance alone does not affect the time constant. It diminishes the intensity or strength of the currents only ; but resistance, combined with electro-magnetic inertia, and with capacity, has a serious retarding effect on the rate of rise and fall of the currents. They increase the time constant and introduce a slowness which may be called *retardance*, for they diminish the rate at which currents can be transmitted. Now, the retardance due to electro-magnetic inertia increases directly with the amount of electro-magnetic inertia present, but it diminishes with the amount of resistance of the conductor. It is expressed by the ratio L/R, while that due to capacity increases directly, both with the capacity and with the resistance, and it is expressed by the product K R. The whole retardance, and, therefore, the speed of working the circuit or the clearness of speech, is given by the equation

$$L/R + K\,R = t,$$

or

$$L + K\,R^2 = R\,t.$$

Now in telegraphy we are not able altogether to eliminate L, but we can counteract it, and if we can make $R\,t = 0$, then

$$L = -K\,R^2,$$

which is the principle of the shunted condenser that has been introduced with such signal success in our Post Office service, and has virtually doubled the carrying capacity of our wires.

If in the above equation we make $L = 0$,

$$K\,R = t.$$

This is done in telephony, and hence we obtain the law of retardance, or the law by which we can calculate the distance to which speech is possible. All my calculations for the London and Paris line were based on this law, and experience has shown it to be true.

How is electro-magnetic inertia practically eliminated? First by the use of two massive copper wires, and secondly by symmetrically revolving them around each other. Now L depends on the geometry of the circuit, that is, on the relative form and position

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of the different parts of the circuit, which is invariable for the same circuit, and is represented by a coefficient, λ. It depends also on the magnetic qualities of the conductors employed and of the space embraced by the circuit. This specific magnetic capacity is a variable quantity, and is indicated by μ for the conductor, and by μ_0 for air. It depends also on the rate at which currents rise and fall, and this is indicated by the differential coefficient $d\,C/d\,t$. It depends finally on the number of lines of force due to its own current, which cut the conductor in the proper direction; this is indicated by β. Combining these together we can represent the electro magnetic inertia of a metallic telephone circuit as

$$L = \lambda\,(\mu+\mu_0)\,d\,C/d\,t\times\beta.$$

Now, $\lambda = 2\log d^2/a^2$. Hence the smaller we make the distance (d) between the wires, and the greater we make their diameter (a), the smaller becomes λ. It is customary to call the value of μ for

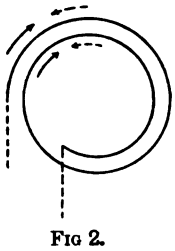

Fig 2.

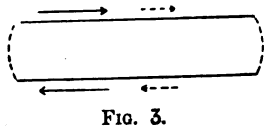

Fig. 3.

air and copper, 1, but this is purely artificial and certainly not true. It must be very much less than one in every medium, excepting the magnetic metals, so much so that in copper it may be neglected altogether, while in air it does not matter what it is, for by the method of twisting one conductor round the other, the magnetisation of the air space by the one current of the circuit rotating in one direction is exactly neutralised by that of the other element of the circuit rotating in the opposite direction. Now, β, in two parallel conductors conveying currents of the same sense, that is flowing in the same direction, is retarding (Fig. 2), and is therefore a positive quantity, but when the currents flow in opposite directions, as in a metallic loop (Fig. 3), they tend to assist each other and are of a negative character. Hence in a metallic telephone circuit we may neglect L *in toto*, as I have done. I have never yet succeeded in tracing any evidence of electro-magnetic inertia in long

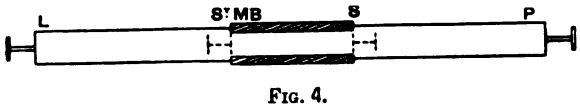

Fig. 4.

single copper wires, while in iron wires the value of L may certainly be taken at ·005 henry per mile.

In short, metallic circuits, say of lengths up to 100 miles, this negative quantity does not appear, but in the Paris-London circuit this helpful mutual action of opposite currents comes on in a peculiar way. The presence of the cable introduces a large capacity practically in the centre of the circuit. The result is that we have in each branch of the circuit between the transmitter, say, at London and the cable at Dover, extra currents at the *commencement* of the operation, which, flowing in opposite directions, mutually react on each other and practically prepare the way for the working currents. The presence of these currents is proved by the fact that when the cable is disconnected at Calais, as shown in Fig. 5, and telephones are inserted in series, as shown at D and D', speech is as

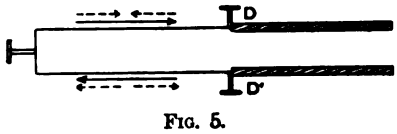

Fig. 5.

perfect between London and St. Margaret's Bay as if the wires were connected across, or as if the circuit were through to Paris. Their effect is precisely the same as though the capacity of the aerial section were reduced by a quantity (M), which is of the same dimension or character as K. Hence our retardance equation becomes

$$R\,(K-M)=t.$$

Thus it happens that the London-Paris telephone works better than was expected. The nature of M is probably equivalent to about ·0075 ϕ per mile, and, therefore, K should be also about ·0075 ϕ, instead of ·0156 ϕ per mile. This helpful action of mutual induction is present in all long circuits, and it is the reason why we were able to speak to Brussels and even to Marseilles. It also appears in every metallic loop, and vitiates the measurements of electro-magnetic inertia and of capacity of loops. Thus, if we measure the capacity of a loop as compared with a single wire, the amount per mile may be 50 per cent. greater than it ought to be; while if we measure the capacity of one branch of a circuit under the conditions of the London-Paris telephone line, it may be 50 per cent. less than it ought to be. This effect of M is shown by the dotted line in Fig. 1.

Telephonic currents, that is, currents induced in the secondary wire of an induction coil due to the variation of microphonic currents in the primary wire, are not alternating currents. They do not follow the constant periodic law, and they are not true harmonic sine functions of the time. The microphonic currents are intermittent or pulsatory, and always flow in the same direction. The secondary currents are of the same sign, as are the currents in a Ruhmkorff coil, and as are the currents in high vacua with which Crookes has made us so familiar. Moreover, the frequency of these currents is a very variable quantity, not only due to the various tones of voices, but to the various styles of articulation. Hence the laws of periodic alternate currents following the sine function of the time fail when we come to consider microphones and telephones. It is important to bear this in mind, for nearly everything that has hitherto been written on the subject assumes that telegraphic currents follow this periodic sine law. The currents derived from Bell's original magneto-transmitters are alternate, and comply more nearly with the law. The difference between them and microphones is at once perceptible. Muffling and disturbance due to the presence of electro-magnetic inertia become evident, which are absent with microphones. I tested this between London and St. Margaret's, and found the effect most marked.

7. *Lightning.*—A metallic telephone circuit may have a static charge induced upon it by a thunder cloud, as shown in Fig. 6. Such a charge is an electric strain, which is released when the charged cloud flashes into the earth or into a neighbouring cloud. If there be electro-magnetic inertia present, the charge will surge backward and forward through the circuit until it dies out. If there be no E.M.F. present it will cease suddenly, and neutrality will be attained at once. Telephone circuits indicate this operation by peculiar and characteristic sounds. An iron wire circuit produces a long swish or loud sigh, but a copper wire circuit like the Paris-London telephone emits a short, sharp report, like the crack of a pistol, which is sometimes startling, and has created fear, but there is no danger or liability to shock. Indeed, the start has more than once thrown the listener off his stool, and has led to the belief that he was knocked down by lightning.

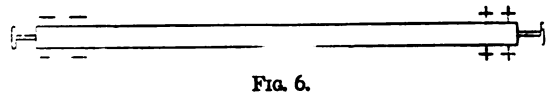

Fig. 6.

8. The future of telephone working, especially in large cities, is one of underground wires, and the way to get over the difficulties of this kind of work is perfectly clear. We must have metallic circuits, twisted wires, low resistance, and low capacity. In Paris, a remarkable cable, made by Fortin-Herman, gives an exceedingly low capacity, viz., only ·069 ϕ per mile. In the United States they are using a wire insulated with paper which gives ·08 ϕ per mile. We are using in London Fowler-Waring cable giving a capacity of 1·8 ϕ per mile, the capacity of gutta-covered wire being 3 ϕ per mile.

ON THE TELEPHONING OF GREAT CITIES.*

BY A. R. BENNETT.

A matter which has never yet been seriously faced is how the demand for telephonic exchange connection, which, after the lapse of a few more years, is bound to arise in all large cities, is to be met. What is possible in this direction under the influence of moderate rates and a reasonably efficient service has already been demonstrated in certain localities, chiefly in Scotland, where towns boasting of next to no manufactures or staple trade possess exchanges far exceeding in importance those of many English towns of three and four times the population, the principal supporters of such exchanges, after the manufacturers and merchants, being professional men, as doctors, solicitors, and accountants; householders; and shopkeepers, as grocers, butchers, and druggists. The efficiency and the readiness with which a large town or city can be telephoned so as to meet the ever-increasing demands of the inhabitants will depend, in a very great measure, on how the work is laid out and set about in the initiatory stage. If London were telephoned in the same proportion as Galashiels, it would possess 28,000 subscribers; but that number does not nearly represent the

* Abstract of a Paper read before the British Association, in Section G, at Cardiff, August, 1891.

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possibilities—far from it. We must certainly anticipate one telephonic exchange connection for every 50 inhabitants in London in time to come; a modest estimate, if we consider that there is already one for every 200 inhabitants in Galashiels and some other towns, which are the merest hamlets in comparison. With London's present population of 5,600,000 such a proportion would represent 112,000 subscribers, and, as the population increases and the boundaries extend, more and more will grow the demand, until even that great number will appear inadequate and insignificant. As an indication of how the telephone idea is taking root, I may mention that the builders of a new block of business offices in Manchester propose to put a permanent connection to the Mutual Telephone Company's Exchange into each suite of offices, paying the subscriptions themselves, and charging their tenants nothing extra. This is one of the first-fruits of cheap rates.

The establishment of an effective and popular telephone exchange in a large town, and one that can be added to and extended freely and economically, without pulling down what has already been done, involves the fulfilment of several indispensable conditions. Firstly.—Speech must be loud and distinct, and privacy of communication complete; and a subscriber's line and apparatus must be adapted equally well to speaking to another across the street or to one five hundred miles away. There must, furthermore, be an absence of all disturbing sounds. Secondly.—The arrangements for connecting the subscribers together, subsequently disconnecting them, and, if required, immediately re-connecting them to others, must be so complete that eight or ten seconds should be the maximum time occupied within the compass of the largest town. Thirdly.—The rates must be within the reach of even small householders and shopkeepers, and should not exceed £8 per annum. Fourthly.—The general design must permit of the addition of new subscribers in every direction and to any extent, without interfering with the work already done. All these conditions can be complied with. What is necessary to do to meet them can be broadly indicated under three headings. (1) The universal use of metallic circuits, and the absence from the line of intermediate electro-magnets and other signalling devices which tend to damp and deform the electrical vibrations which constitute telephonic speech. (2) The provision of means by which certain and instantaneous communication can be established between subscriber and operator, and between one operator and another, (3) The division of the town to be telephoned into districts or sections not exceeding a square mile in area, each of which is worked from a switch-room placed at or near its centre.

The fulfilment of these necessary conditions is easy, provided the undertakers are in possession of the right to open the streets. So long as the execution of any scheme is subject to the caprice or the blackmailing propensities of individual proprietors, a proper telephonic service, such as London, the first city of the world, ought to possess, will remain an aspiration and nothing more. Legislative assistance to the extent of placing the undertakers of telephone exchange systems on an equal footing with the ministers to other public wants is indispensable to the carrying out of a scheme designed not only to meet the requirements of the moment but those of a reasonable number of years to come. Without such legislative assistance, which, I contend, cannot consistently be withheld, seeing that it is granted as a matter of course to railway, tramway, and other companies, the efficient and economical telephoning of great cities verges so near to the impossible that, during the remainder of my Paper, I shall assume that it will be forthcoming at the proper time.

As already indicated, the system of the future for all large towns must be founded upon the use of multiple switch-rooms, each serving its own immediate neighbourhood. All the subscribers' lines will then be short and economical to construct, while the switching apparatus, owing to sub-division, will be simple and cheap. These conditions will enable the annual payments by subscribers to be kept down to a minimum. All subscribers' lines will be metallic circuits. To the British Post Office (in the person of Mr. W. H. Preece) belongs the honour of being the first to insist on the necessity of double wires for telephone exchanges. When the Mutual Telephone Company started in Manchester, I advised them to have nothing to do with single wires, but to secure privacy and freedom from disturbing noises by using nothing but metallic circuits.

To obtain an efficient service with multiple switch-rooms by the aid of the switching apparatus ordinarily used in this country, with its intermediate electro-magnets and numerous complications, would be out of the question. A radical departure from existing practice must be made in this, as in other particulars. Fortunately, the way out of the difficulty lies ready to our hand.

For a good many years now a system known as the "Mann" has been operated with the greatest possible success in several districts, principally in Scotland. This system is unrivalled in many respects. It enables connections to be obtained with certainty and celerity; it renders easy the task—on some of the older exchanges an arduous and frequently impossible one—of getting rid of one connection and obtaining another. It simplifies and cheapens switching apparatus to an almost incredible degree, and it permits of connections being made through many switch-rooms without the intervention of intermediate electro-magnets, so that no retardation and indistinctness of speech results. The system possesses other conspicuous merits, but it is unnecessary to enlarge on them here. In one respect, and in one only, is the "Mann" system apparently more complicated and more expensive to instal than the ordinary. It necessitates the taking into each subscriber's office of a branch from a common service wire, on which all communications with the operators are conducted, and the addition to each subscriber's instrument of an extra piece of apparatus. But the complication is more imaginary than real, while the extra cost of the service wire and fittings is saved many times over in the switch-room, where an infinity of complicated and expensive apparatus is dispensed with, and where faults, and attendance by skilled electricians, are reduced to a minimum.

The main feature of the system is the service wire already mentioned. One such wire is allotted to every 60 to 100 subscribers, according to the amount of traffic passing. During the busy hours of the day operators are always listening on the service wires, so that subscribers may speak and be heard without any premonitory signals. By means of specially-constructed telephones, weighing but a little over two ounces, attached to the head by springs, the girls are enabled to listen continuously without fatigue, and at the same time keep both hands free for operating purposes. The subscriber, on his part, can at any moment place himself in communication with the operator by depressing a small lever, which has the effect of changing his instrument temporarily from his main line to the service wire. The mere depression of the lever suffices to secure her attention at any moment, so that mistakes can immediately be rectified and an explanation asked of any delay. The

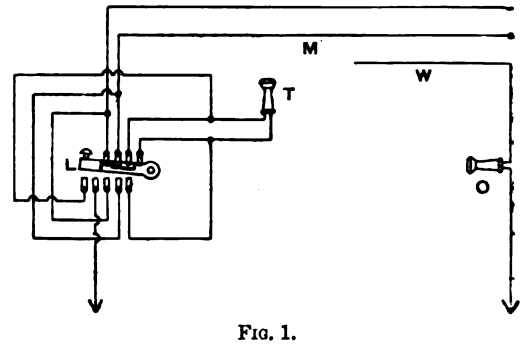

FIG. 1.

L, Subscriber's lever, changing his telephone from metallic circuit to earth.
M, Subscriber's metallic circuit forming, when lever is depressed, the subscriber's side of the condenser.
O, Operator's telephone.
T, Subscriber's telephone.
W, Insulated wire, forming operator's side of the condenser,

operators have not to do any ringing at the Exchange, the subscribers working their own call bells, thus leaving the girls to perform only the acts of connecting and disconnecting, a feature which greatly contributes to the rapidity for which the system is famed. A deal of labour is also saved by the absence of the ordinary shutter indicators, the putting up of which, after they have been dropped by the subscribers, constitutes a large part of the operator's work with other systems. The operator's telephone is always earthed: those of the subscribers only when their levers are depressed.

The experience gained at Manchester has enabled the one objection to the "Mann" system—the necessity of taking an additional wire into each subscriber's office—to be overcome. After having designed and partially constructed the Manchester Mutual Exchange on the "Mann" system, it occurred to me that it might be possible to convey the service messages between subscribers and operators by means of electrostatic induction between the subscriber's metallic loop and a special single wire run out for a sufficient distance from the Exchange amongst each group of metallic circuits.

On arranging the wires and apparatus in the manner indicated in Fig. 1, it was found that such a plan was really practicable. The connections of the subscriber's instrument were altered in such a way that, on depressing the lever, the metallic circuit (represented by M in the Diagram) was put to earth through the telephone. The metallic circuit then acted as a single wire of double area, and, whether insulated at the switch-board or connected through to another circuit, practically formed one plate of a condenser, the other plate or plates of which were any of the adjacent wires that happened to be earthed at their extremities. It was, therefore, only necessary to put the operator's instrument in permanent connection with one or more wires running parallel to the subscriber's metallic circuit for a short distance, to enable

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any of the subscribers, whose instruments were so fitted, to communicate with the operator by depressing their levers. When the levers were not depressed, the telephones were looped in the metallic circuits as usual, and the operators could neither hear nor be heard.

When cables were used containing 36 or even 72 metallic circuits, it was only necessary to connect the operator's telephone to a single wire placed in the centre of the cable, or to the metallic sheathing of the cable, to obtain perfectly good speaking when the metallic loops were earthed by the subscribers depressing their levers.

When a connection has to be obtained through more than one switch-room it is asked for by each operator in succession by depressing a lever which puts her in communication with a service wire on which the operator at the next switch-room is listening.

I have recently devoted considerable thought to the problem of telephoning a great city like London. I have taken as a groundwork an area of 32 square miles, measuring eight from west to east, and four from north to south. Such an area would comprise the greater part of London, from Shepherd's Bush to Limehouse, and from Primrose Hill to Kennington Oval, and include the chief of the telephonic wealth of the metropolis.

In considering my plan, I have kept steadily in view the conditions I have stated to be indispensable, putting efficiency first and economy second, although, as it happens, I have found the two march well together. With the Mutual system vanishes the whole costly and complicated paraphernalia of American switch-room apparatus which has been so blindly copied in this country. As an instance of the economy effected, I may mention that in a switch-room fitted for 5,000 subscribers the first cost per subscriber on the American plan is about £3. 10s. for switching apparatus alone; on the Mutual plan adopted at Manchester, the cost per subscriber is about 10s. The difference in cost of maintenance is even more striking, while the efficiency is altogether in favour of the cheaper method.

As already indicated, I propose to telephone any large town by dividing it into sections about a square mile in area. In the centre of each square I would place a switch-room, making 32 sectional or branch switch-rooms in an area of 32 square miles. According to the configuration and general requirements of the town, I would establish one or two central switch-rooms. The subscribers in each section would be connected, each by a metallic circuit, to their appropriate switch-room, and the sectional switch-rooms would, in their turn, be connected to the central rooms by as many metallic circuits as the traffic passing through them may be found to require. In addition there would be, between the switch-rooms, a sufficient number of service wires—that is to say, metallic circuits reserved entirely for service communications between the operators. The mode of operation may be either the "Man" plan pure and simple, or the modification of it, which I have described. The subscribers' lines could be distinguished, as is usual, by numbers. The use of very high numbers could be avoided by assigning each switch-room a distinguishing name or code-word, and numbering its subscribers from one upwards. The central switch-room need not be exclusively reserved for operating junctions. It would probably be found advantageous to connect direct to it subscribers in its immediate vicinity, and for these a separate switch-board could be provided.

APPENDIX.

On an existing exchange worked according to Mann's system, each operator in ordinary course of business, deals with 180 connections per hour, or exactly three per minute, of which about half have to be obtained from, or given to, operators at other switch-rooms. On a special trial being made, by several inspectors being put on an operator's service wire, with instructions to supplement the ordinary traffic by demanding connections incessantly, the operator successfully dealt with 357 connections in exactly one hour. She therefore got through 5·95 per minute for 60 consecutive minutes, which gives an average for each connection, *including subsequent disconnections* of 10·09 seconds. Of these she completed 92 herself, 223 had to be asked from another switch-room, and 42 were given to another switch-room. All the usual incidental work was properly performed, such as informing callers that the subscriber wanted was engaged; ringing up callers, and notifying that the subscriber previously advised as engaged could now be had; answering repeated demands from impatient callers for engaged or dilatory subscribers; informing operators at other switch-rooms that subscribers wanted could not be had, with the reasons, and subsequently advising that they were free.

Special tests were made to ascertain the rate at which connections involving the attention of three different operators could be completed and subsequently got rid of. For this purpose a model conversation was arranged, each subscriber, on being rung up, being told, "This is the Telephone Manager's Office; is there one of my inspectors at your place just now?" Two tests were made, in each case 20 consecutive connections being demanded with subscribers taken at random from the list, except that only those were selected whose connections, owing to the position of their premises, would have to be handled by three operators. It was agreed before hand that if any subscriber called for left his bell unanswered for 60 seconds the experimenter would tell the operator to disconnect and give another. The tests took place during busy hours of the day, and were imposed on the ordinary traffic. Test A.—Twenty connections were made, but the twelfth subscriber asked for did not answer within the regulation minute, so that only nineteen model conversations were held. The first connection was asked at 10h. 1m. 0s., and the twentieth was done with at 10h. 19m. 40s. Deducting one minute lost over the subscriber not obtained, the average for the nineteen conversations had was 55·8 seconds. Test B.—Twenty connections were asked for, but one subscriber was engaged, and two others did not answer within the regulation minute; consequently only seventeen model conversations were held. The first connection was asked at noon precisely and the twentieth was done with at 12h. 14m. 20s. Deducting three minutes lost over the three not obtained, seventeen conversations were completed in 11m. 20s., giving an average of 40 seconds per conversation. Of the 680 seconds occupied, only 136 were taken up in asking for and making the connections; the balance was consumed in ringing the subscribers called, by their delay in answering, in putting the model question, and receiving the replies, which were not always confined to a monosyllabic negative.

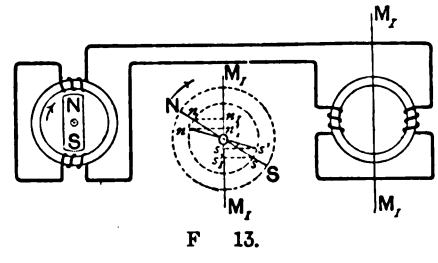
THE ELECTRIC TRANSMISSION OF POWER.*

BY GISBERT KAPP.

LECTURE III.

(Concluded from page 448.)

Owing to the low efficiency and small power of the two-wire revolving field motor, its employment is necessarily restricted to cases where these defects are of little consequence, but for the transmission of large powers over long distances it is not suitable. For such a purpose we must have three wires, but this is not a great drawback since the cost of the line is but little increased by the necessity of splitting up the total weight of copper into three instead of into two wires. The revolving field motor has, however, the defect that it is not self-regulating. Its speed may be anything between zero and that speed which will give synchronism between the two machines accordingly as the mechanial load varies from a maximum to nothing. This defect can be overcome by combining with the armature in the motor a real magnet which will force the armature to keep step with the current, and thus insure a constant speed at varying loads. The motor will thus start with great power by virtue of the currents induced in the armature-winding by the revolving field, and having reached the synchronising speed it will keep there by virtue of the interaction between the revolving field and the revolving magnet; it will, in fact, behave just like an ordinary alternator run as a motor, with this difference, however, that the ordinary alternator, if overloaded by 50 or 100 per cent., will be thrown out of step and come to rest, whereas the combined Ferraris and synchronising motor will always be ready to recover itself after the overload has been removed.



F 13.

Since the discovery of Ferraris has been made public, many engineers have turned their attention to revolving field motors, and especially to a modification of this principle, according to which three sets of coils are employed instead of two sets only. As far as I have been able to trace the history of this invention, the first to suggest the use of three coils were M. Tesla and Charles Bradley. The latter applied in the United States for a patent in 1888, which bears the number 409,450, and was granted on August 20, 1889. Next comes Wenstrom with his British patent, No. 5,423, of 1890, and at about the same time Dobrowolsky, in Berlin, had worked out a similar system. About a year ago, when I visited him at the works of the Berlin Electrical Company, he showed me such a three-wire motor in action, whilst shortly afterwards Charles Brown, of Oerlikon, took the matter up, and it may interest you to learn that he is at the present

* Cantor Lectures delivered before the Society of Arts, February and March, 1891.

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moment putting up a 500 H.P. transmission plant on this system between Bülach and Oerlikon, a distance of 15 miles. This transmission is intended to supply all the power required in the Oerlikon Works. The general principle forming the basis of the work done by these various inventors is illustrated in Fig. 13. The generator contains a revolving field magnet, and an armature wound with three distinct coils. The end, O, of each coil is joined to a wire, W, common to all, and the three free ends are joined with the three-line wires. At the receiving station there is a three-legged magnet, the coils on the legs being in connection with the line wires on the one side, and jointed by a common wire, W, on the other side. It is easy to see that the rotation of the field magnet in the generator will produce successive polarities in the legs of the receiving magnet, and that the general effect will be that of a revolving field. The armature, A, will, therefore, be set in rotation in the same way as is the case in the original Ferraris motor. This kind of transmission is known in Germany under the name of transmission by the "three-phase current," and it is likely that it will, ere long, become a strong rival to the ordinary alternating current.

The diagrams I have brought before you were all drawn for two-pole machines, as this was the simplest way of making the principles clear; but I need hardly say that, in practice, the machines are made of the multipolar type, in order to bring the speeds down to any desired value.

You will, perhaps, ask why we should go to the complication of three-line wires and a totally new type of motor, seeing that, with the ordinary dynamos and motors, such excellent results have been obtained, and that with only two-line wires. My answer is that, with this new system, we can greatly extend the distance of transmission. I have spoken, a short time ago, of the difficulties which the high voltage required in long-distance transmission raised in connection with the commutators and general insulation of machines. Now, in the three-wire system of transmission, by alternating currents, we have no commutators, and, in fact, not even rubbing currents. One of our difficulties has, therefore, already vanished. As to the other, which has reference to the general insulation of the machines, it is easy to see how this may be overcome. We need only, instead of working direct, work through transformers. The insulation of transformers offers no difficulty whatever. I have here on the table a transformer of the type made by Messrs. Johnson and Phillipps, which has been designed specially for high-pressure currents, and is provided with oil insulation. I have recently used two of these transformers for testing a Brook's line. In one transformer the pressure was raised from 2,400 to 17,000 volts, the high-pressure current was sent through the line, and, at the other end, it was again transformed down to 2,400 volts, and, finally, to 100 volts, for lighting glow-lamps. The apparatus was kept running for several days without any difficulty. Mr. Brown informs me that he has with oil insulated transformers, even gone up to 36,000 volts without breaking down the insulation, and the Bülach-Oerlikon transmission will be made at 25,000 volts, whereas the machine will work only at a few hundred volts. There is thus no difficulty in adopting whatever voltage is most economical in each case, and yet avoiding all danger, either to the attendant or to the machines themselves, at the generating and motor station.

I feel that I owe an apology for having occupied so much of your time with discussing a branch of power transmission which, to many of you, must seem to be purely theoretical, and hardly ripe for discussion. My excuse must be that I am very strongly convinced that some form of alternate current working will be the ultimate solution of the problem how to transmit power—possibly over all distances, but certainly over very long distances—and that I was desirous of directing the attention of electrical engineers to a subject in which much work may still be done.

Electric Machine Tools.

In concluding my lectures, I wish to bring before you a few examples of short distance transmission as applied to electric machine tools. This branch of our subject has of late years received considerable development at the hands of various English firms, and, thanks to their enterprise and perseverance, is now a well-established method in several engineering works.

As an example, I may mention the Leven Shipyard of Messrs. Denny Brothers, at Dumbarton, and Mr. Archibald Denny has been good enough to give me some particulars of the work carried on by his firm in this direction. I cannot do better than quote his words:—"In our yard and engine works we have numerous instances of electric transmission of power. In our experimental tank we drive our model cutting machine and small lathes by means of a 3 H.P. Immisch motor. In our upholstery department we drive six sewing-machines with a 2 H.P. Immisch motor; of course in this case there is a large margin of power. In our experimental tank we have also used small motors for driving small model paddle wheels in our experimental models, and have obtained in this way most valuable data, which we could not have got by any other means. The power for all this work is obtained from a dynamo driven by an ordinary line of shafting in our joiner's shop. We also use a 3 H.P. motor in the yard for boring the stern tubes in place; before this we used a portable engine, which necessitated an attendant to fire the boiler and carry water to it. During the holidays, when all the boilers are off except one, we occasionally put down a motor for driving some lathes to do repair work, and this saves an attendant at more than one boiler. In our engine works the pattern shop is driven by a 15 H.P. Manchester motor, the dynamo being driven off the line of shafting in the fitting shop."

You see, Messrs. Denny Brothers find electric power transmission so handy, economical, and convenient, that they make extensive use of it. They employ a special tool for drilling the sole plates of engines, which I now show on the screen. The weight of the machine is sufficient for the pressure required on the drill, and the whole apparatus being mounted on wheels it can be rapidly shifted. The machine will drill 1¼in. holes through two thicknesses of inch plate in three minutes.

Another machine used at Leven Shipyard is a special drill for butt straps. The motor and gear are mounted on a stout vertical column with horizontal arm, so as to give adjustment in both directions, the column being bolted to the strap, as shown. The machine will take in straps 50in. deep by 23in. between outer rows of holes, and is chiefly used for drilling sheer strake double butt straps. The outside strap is first punched and counter-sunk, and the machine drills through the plate and inside strap. The machine is worked by two men—one hole-borer and one labourer—and will do three straps, or about 180 holes per day.

The rivet holes in boiler furnaces are also drilled by an electric tool, which I illustrate on the screen. The machine has a tripod stand arranged to go inside the furnace, but it has also holding-on magnets for outside work. One man with this machine does the work which formerly required three to four men.

No account of electric machine tools would be complete if it did not include the work done by Mr. Rowan, who has been very successful in developing this branch of power transmission. Amongst the improvements Mr. Rowan introduced is that of holding-on magnets, whereby the tools are firmly held in place while at work, and yet by the mere turning of a switch become liberated and can be shifted to a new position with the greatest ease. You see on the screen some of Mr. Rowland's drillers as applied to ship work. The apparatus is suspended on a chain over the ship's side, and supplied with current by means of two flexible wires. I need not detain you with a description of the picture on the screen because I can show you the actual machine at work, thanks to the kindness of Messrs. M'Whirter, Fergusson and Co., the makers, who have sent me one of their latest machines for this lecture.

I am also indebted to Mr. Webb, the locomotive superintendent of the London and North-Western Railway, for the loan of one of his electric tube cutters, which you see before you, and which I shall now work. A diagram of this machine to an enlarged scale is on the wall.

These few examples of what are properly called electric machine tools must suffice for this lecture, but there is another class of apparatus, namely, electric mining machines, which ought to be included in our subject. Several firms, both here and abroad, have of late years devoted considerable attention to the application of electric power to mining operations, such as pumping, hauling, coal-cutting, and drilling. Messrs. Goolden and Co., for instance, have during the last four years steadily and perseveringly worked out many of the difficult problems in connection with this subject, and I am indebted to this firm for the loan of the apparatus you see here, and also to Mr. Atkinson for assisting me in setting the machines up. After the excellent Paper which Mr. Atkinson read at the Institution of Civil Engineers, only a few weeks ago, it would be occupying your time uselessly if I were to give any lengthy description of these machines. I shall, therefore, merely show two types of mining motor on the screen, and show you a drill at work.

I have in these lectures not attempted to treat exhaustively any one branch of the subject, but have rather endeavoured to pass the various branches in rapid review, so that you may know what electric transmission of power can do and what it cannot do. We hear now-a-days very frequently the assertion that electricity is but in its infancy and will ere long be the sole motive power, driving our main-line trains, speeding our vessels across the ocean, and running our factories. These are idle dreams, ideas put forward by persons who have forgotten, or have never learned, the fundamental laws of nature. Do not waste time over such ideas, for there are other more hopeful problems, such as the utilisation of water-power generally, of waste coal at the pit's mouth, the working of railways in mountainous districts, where water-power is abundant all along the line, the working of tramways, underground town railways, the application of electric power to such purposes for which now small auxiliary steam engines are employed, and last, but not least, its application to machine tools and other special machinery, of which I have given you examples to-night.

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THE LIGHTING OF RAILWAY TRAINS ELECTRICALLY.*

BY ILLIUS A. TIMMIS.

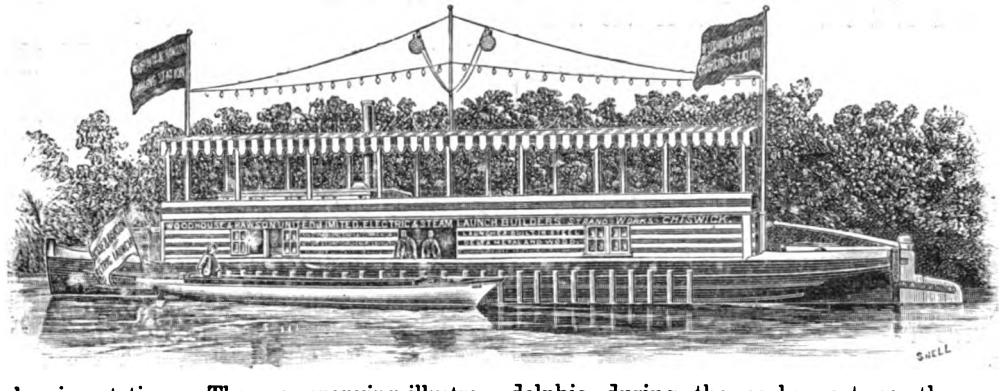
The author is of opinion that it is not advisable, here, to enter on any lengthened dissertation as to the relative merits of oil or gas or electricity as a means of lighting, as such, to be complete, would involve many intricate side issues connected with the expense of first cost, and the attendant and complex ones of maintenance and labour.

After stating the primary conditions to be observed in train lighting by electricity, and discussing the relative merits of axle driving, driving from a special engine on a train, and charging accumulators from plant employed to light large stations and goods-yards, the author describes the arrangements which he has found most suitable and economical for carrying out the above conditions and getting over all difficulties. He fits the carriages with 16 c.p. 50-volt lamps, and lights these lamps either with a special engine and dynamo on the train, or with a battery consisting of 26 accumulators placed in the guard's van. But as each carriage ought to carry its own store of electricity, and as it is not practicable to put 26 (or even 18) cells in each vehicle, he has worked out the following arrangement, his main object being to minimise the weight and cost of electric batteries. In addition to the main lighting, he places low voltage lamps (eight volts) in the carriages and a small four-cell battery in each carriage to light them. These small lamps are so arranged that as soon as a pair of couplers are separated they are automatically lighted in the carriages that are separated from the main circuit by the small batteries. They are also under the control of the guard. The small batteries are very light (weighing per carriage less than 1cwt.), they are not costly, and they are kept charged by the engine and dynamo or the main battery in the guard's van as required. Thus every carriage is free to be used in any train, and the only batteries that require special arrangements for charging, if any, are those in the guard's vans.

It must be remembered that the only times the auxiliary lamps are used are when a vehicle is taken off a train and perhaps put, for a few minutes, at the longest, into a siding and then joined on to another train, or when a vehicle is slipped from a train and while it is brought to a stop at the station, and during this time the auxiliary batteries give 6 to 8 c.p. in each auxiliary lamp. In the case of division of a train, for instance, where a long train of some 20 or more coaches splits up into, say, three divisions, then each division has at least one guard's van, and so it is, electrically and otherwise, if main batteries are used, a complete train; and if special engines and dynamos are used, the lighting is equally complete.

ELECTRIC LAUNCH FLOATING CHARGING STATION.

The number of electric launches upon the upper reaches of the Thames is constantly on the increase, and the business proves exceedingly remunerative to those engaged in it. An indispensable adjunct to an electric launch fleet are conveniently situated and well organised charging stations. The accompanying illustration shows a floating charging station, in appearance very similar to a house-boat. Each station consists of a river barge 80ft. long and 14ft. beam. The machinery is placed in a compartment at one end, and consists of a semi-portable steam-engine plant and dynamo of sufficient output to charge the accumulators on six launches simultaneously. The remaining portion of the boat contains a store-room, an office, sleeping apartments for the attendants, and an engineer's room, where a lathe is fixed and attendants are kept constantly in readiness to effect any repairs to launches which may be required.



Messrs. Woodhouse and Rawson United, to whom this floating station belongs, have also established stations at Kew, Chertsey, Windsor, and Abingdon.

* Abstract of a Paper read before the British Association, in Section G, Cardiff, 1891.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *August* 15, 1891.

Meeting of the Edison Association.—The annual meeting of the Association of Edison Illuminating Companies has been held at the Murray Hill Hotel in this city during the present week. A large number of Papers were read, some of them of great interest, but as usual the meetings were secret, and consequently no information of any value has crept out. A report of the proceedings has been furnished to the journals for next week, but it has been edited to such an extent as to prove of very little real value. Of course facts showing that the operation of the Edison station is not always perfect will crop out with unfortunate frequency, and these must be suppressed at all hazards. The Edison Company, by the way, has been losing some of its best engineers recently; Mr. Jackson, the Western district engineer, resigned a short time since to take the position of professor of electrical engineering in the University of Wisconsin, and Mr. H. Ward Leonard, for some time the head of the light and power business of the Edison Company, has also found it to his interest to abandon that organisation and go into business for himself. The reasons alleged for this move are various, but such changes have become sufficiently frequent since the last reorganisation of the Company to attract very little attention; in fact they are expected. Mr. Leonard has formed a new company and will occupy himself with general electrical engineering.

Electric Railway Work.—Of the large electrical companies there is comparatively little to be said. The Thomson-Houston Company is exceedingly busy, and doing an immense amount of work, especially in the railway and motor departments. The Edison Company is confining itself more strictly than ever to incandescent lighting, and the railway business especially seems to be slow in developing. Of the new single reduction gear motors, manufactured by this Company, and mentioned in one of my letters some time since, nothing has been heard. It is reported that orders have been taken and some machines have been sent out, but everybody is in profound ignorance as to where they have gone, or whether the machine is a success. The Westinghouse Company is going quietly along, and transacting quite a little business in spite of its financial embarrassments.

Waddell-Entz Accumulator Car.—The Waddell-Entz accumulator car, which made such a successful showing in Philadelphia during the early part of the summer, has been undergoing tests at Chester, Pa, and has acquitted itself remarkably well. The batteries seem to hold out well, and the motor leaves little to be desired. In view of the very broad Brush decision *re* storage batteries, the advent of this latter system is particularly interesting, although it is claimed by some that it—like the lead batteries—will be swept up by the "drag-net" claim that Brush was allowed to pass through the Patent Office, and that has been since sustained.

The Greathead Tunnel System in New York.—The report of the first half-year's working of the City and South London Railway has attracted a great deal of attention here, especially among practical railroad men. A very strong clique in this city favours the adoption of the tubular iron tunnel for the

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rapid transit system to be at some time in the dim future laid down on Manhattan Island. Just what organisation is pushing this particular matter it is impossible to determine. Mr. F. J. Sprague, the well-known electrical engineer, has come out in its favour in such an outspoken fashion as to suggest that he will be likely to take a hand in the electrical work if the aforesaid system should be used. The engineers of the Rapid Transit Commission are still engaged in their secret deliberations, working up an agglomerated plan at the expense of the unfortunate experts who have put time and money into laying well-considered methods of construction before the Commission. It is generally understood that the engineers are working on a combination of the Greathead iron tunnels and a double-deck single tunnel to accommodate four tracks.

SCANDINAVIAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

COPENHAGEN, *August* 22, 1891.

Although Norway cannot vie with Sweden as regards the use of the telephone, this instrument is being more and more adopted there. The number of subscribers in Christiania now exceeds 2,700. In addition, there are 300 subscribers to independent telephone companies, outside Christiania, that have connection with the Christiania Telephone Company. The number of conversations is about 15,000 per working day.

The Swedish State Telegraphs have had printed a complete catalogue over their telephones, which is quite a formidable volume, consisting of 379 pages, with maps and tables of the various rates for telephoning. Since the last catalogue, which was published on November 15th, last year, the number of subscribers has increased by 2,189 (from 987 to 3,176). The number of exchanges has risen from 34 to 73.

The Swedish State Telegraphs have obtained the permission of the Government to immediately commence work on the following telephone trunk lines:—Gothenburg-Malinö, Gothenburg-Jönköping, Stockholm-Upsala, Pitea-Glaporonda, Uddevalla-Strömstad. The new lines are calculated to entail a total expenditure of about £9,600. The Swedish State telegraphs had, at the beginning of the present year, cables and lines of an aggregate length of 8,785 kilometres, and wires of an aggregate length of 22,884 kilometres. The rated telegrams, during 1890, numbered 1,755,345, those not rated 65,331, making altogether 1,820,676 messages, or 46,593 more than during the previous year. The receipts on the telegrams paid for amounted to 1,969,895kr., of which 1,412,619kr. represent the net taking of the telegraphs, being 18,286kr. in excess of the figures for the previous year. The length of the telephone lines under the State telegraphs amounted to an aggregate of 12,779 kilometres at the beginning of the present year. During 1890 a sum of 914,067kr. (£45,700) were expended in the development of the State telephones.

The works in connection with the Copenhagen Central Electric Station are now being energetically pushed on. The laying of the cables in the streets is in full swing, and the whole installation is expected to be ready towards the close of the present year.

The month of August has been singularly prolific in thunderstorms in both Denmark, Norway, and Sweden—more so, however, in Denmark than in the neighbouring countries. A large number of casualties have occurred, many fires have been caused by lightning, and a great many lives have been lost. On one day early in this month no less than seven persons were killed by lightning in Denmark alone, all isolated cases, in different parts of the country, some in the fields and two or three in the houses. The cattle have also suffered severely.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

August 17, 1871.

13,865. E. EDWARDS. London. Improvements in apparatus for giving notice, by means of electricity, of the heating of bearings. (A. Backhaus, Germany).

August 18, 1891.

13,917. D. H. SMITH. Glasgow. Improvements in telegraphing.

13,926. L. B. ATKINSON, C. W. ATKINSON, and F. HURD. London. Improvements in electric locomotives and in electric conductors for use therewith.

13,927. H. VAN HOEVENBERGH. London. A unison apparatus for printing telegraphs.

13,942. T. PARKER, J. H. WOODWARD, and E. S. G. REES. London. Improvements in or connected with apparatus for completing and interrupting electric circuits.

August 19, 1891.

13,961. A. R. BENNETT. London. Appliances for an electrical parcel exchange system.

14,023. C. RAAB. London. Improvements in electrometers.

14,040. H. H. LAKE. London. Improvements in electric lighting and extinguishing apparatus for gas burners. (A. Orling, Sweden).

14,042. O. T. COOPER. London. Improvements in electric lamp-holders.

14,063. A. MARR. Manchester. Improvements in telephonic transmitters.

14,067. D. RYLANDS and B. STONER. Stairfoot. Improvements in moulds and machinery for the manufacture of glass switch slabs for electrical and other purposes.

14,084. J. APPLETON and W. T. BURLEY. London. Improvements in electrically actuated time checking apparatus.

14,089. A. RECKENZAUN. London. Improvements in electrical measuring apparatus.

14,096. J. G. THOMPSON. London. Combination electric lock.

14,150. H. MORGAN. London. Improvements in electric fire detectors or alarms. (C. Dion, France).

14,171. G. S. GRIMSTON. London. An improvement in car conductors from overhead for electric cars.

August 22, 1891.

14,217. S. GOSPARE and L. GIACOMINI. London. A new or improved printing telegraphic apparatus.

14,234. M. CATTORI. London. Improvements in and relating to electric railways.

14,236. H. R. LOW and G. E. B. PRITCHETT. Twickenham. An improved method of arranging apparatus for generating and distributing electricity by alternating currents.

SPECIFICATIONS PUBLISHED.

1890.

12,209. HEURTEY and others. Electric meters. (Price 11d.)

12,330. GOURAUD. (Dickerson). Thermo-electric batteries. (Price 6d.)

13,199. GRAHAM. Electric telephone systems. (Price 11d.)

14,693. BAYLY. (Siliceo). Galvanic battery. (Price 6d.)

15,328. ZIPERNOWSKY. Heating by means of electric currents. (Price 6d.)

15,536. COLLIER. Telephone receivers. (Price 8d.)

15,792. MILLS. (Edison). Incandescent electric lamps. (Price 8d.)

16,792. DE PUYDT. Electric arc lamps. (Price 8d.)

1891.

1,192. BUSSER. Propelling boats, &c., by electrical energy. (Price 8d.)

7,160. WALTER. Incandescent lamps. (Price 6d.)

11,118. CLARK. (Tucker and another). Electrical signals for steam vessels. (Price 8d.)

11,145. BATES and HOEVENBERGH. Printing telegraph instruments. (Price 6d.)

TRADE NOTES AND NOTICES.

TENDERS INVITED.—The Corporation of South Shields is desirous of receiving proposals for the laying down, manufacture, supply, and working of the electric light in the borough, a Provisional Order for which has been obtained. Tenders to be sent to Mr. Joseph M. Moore, town clerk, by September 16th.

FOR SALE.—Our advertisement columns contain particulars of a complete electrical installation for sale, in good order, consisting of:—Two pairs of engines, each 75 H.P., high-pressure, non-condensing, 12in. cylinders, 10in. stroke, and two 4-pole Elwell-Parker dynamos, producing 450 amperes at 100 volts, speed 500 revolutions. Further particulars may be obtained of The Manager, Hotel Victoria, Northumberland-avenue, London, W.C.

PERSONAL.—We are informed that Messrs. Drake and Gorham have severed their connection with the Electrical Accessories Company, Limited.

THE GENERAL ELECTRIC COMPANY.—This Company are issuing illustrated particulars of the "Lancashire" Pendulum Movement, which they claim to be efficient, easily mounted, cheap, and reliable. The Company announce that they are able, in consequence of the large demand for the Pendulum Indicators, to make the reductions in price which are set out in the particulars now issued.

MESSRS. DRAKE AND GORHAM.—The electric lighting of Wynyard Park, the seat of the Marquis of Londonderry, is now practically complete, and the light is stated to give great satisfaction. The installation consists of two Davey-Paxman horizontal engines, supplied by two Lancashire boilers, each engine driving a 40-unit Kapp dynamo manufactured by Messrs. Johnson and Phillips. A subsidiary plant has also been installed, consisting of a Robey engine, driving a 15-unit dynamo every night, or when only a small current is required. Upwards of 1,000 lamps are arranged chiefly upon the massive fittings which form a special

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feature at Wynyard. The boilers also supply steam for other purposes, such as pumping and for driving a fire engine. The whole of the installation was designed by Messrs. Drake and Gorham, and carried out under the superintendence of Mr. A. A. Campbell Swinton.

THE RECENT ST. PANCRAS ELECTRICAL EXHIBITION.—We have received from Messrs. H. F. Joel and Co., of Wilson-street, Finsbury-square, E.C., a letter referring to a circular issued by the Committee of this Exhibition, in which Messrs. Joel and Co. figure as debtors on account of their exhibit. Messrs. Joel and Co. complain that they have not been fairly treated, but the grievance is a personal one, and the amount in dispute is very small.

THE IMPROVED BENARDOS PROCESS OF ELECTRIC WELDING.—Messrs. Lloyd and Lloyd inform us that they are enlarging their installation of this process, which they claim to have successfully applied to the manufacture of iron and steel tubes and fittings. A very extensive series of some hundreds of tests has been made by Messrs. David Kirkaldy and Son of bars of various brands of iron and steel, in order to test the nature of the welds, and Messrs. Lloyd and Lloyd state that the results obtained show that a fibrous fracture can be relied upon at the weld with iron, and a silky fracture with steel, and that the contraction of area at fracture and extension, as well as the ratio of weld to solid, are all maintained at high average figures. The firm intend shortly to invite a number of leading engineers to inspect the process at their Works.

"ARCAS" PLATING.—We have received particulars relating to the "Arcas" system of plating on metals. It is claimed by the London Metallurgical Company (Limited), who are the owners of the patents, that the "Arcas" system nas many advantages over silver and nickel electro-plating, and is peculiarly adapted for electrical fittings, instruments, and similar metal work. Some testimonials, which accompany the particulars, speak highly of the work done by the Metallurgical Company.

NEW COMPANIES, STATUTORY RETURNS, &c.

COMBINATION TYRE COMPANY (LIMITED).—This Company was registered on August 22, 1891, with a capital of £2,000 in £1 shares. The objects are:—To acquire and carry on the business of "Markus and Co." To carry on the business of mechanical and electrical engineers, machinists, tube makers, galvanisers, electro-platers, tyre manufacturers, india rubber merchants, &c. Registered without special articles.

DARLASTON CYCLE COMPANY (LIMITED).—This Company was registered on August 18, 1891, with a capital of £10,000 in £10 shares, by Jordan and Sons, 120, Chancery-lane, W.C. Its objects are:—To manufacture cycles of every description, and to carry on the business of mechanical and electrical engineers, electro-platers, wire drawers, metal tube manufacturers, iron and brass founders, machinists, &c. Office: Atalanta Works, Foster-street, Darlaston, Stafford.

ELECTRIC WELDING COMPANY (LIMITED).—This Company has been formed with a capital of £460,000, divided into 45,000 ordinary shares of £10 each, and 1,000 founders' shares of £10 each. The prospectus states that the present issue consists of 25,000 ordinary shares, and the founders' shares, of which issue the vendors take 8,333 ordinary shares. The shares are payable—10s. on application, £3. 10s. on allotment, and £2 two months after allotment. The ordinary shares will be entitled to a cumulative dividend of 10 per cent., and the surplus is to be divisible, one half each upon the ordinary shares and upon the founders' shares. The Directors include Captain A. H. Chapman, J.P., of Messrs. Clarke, Chapman, and Company Victoria Works, Gateshead-on-Tyne; Mr. William F. Gooch, J.P., Managing Director of the Vulcan Ironworks Company, Limited; and Mr. Joseph Kincaid, of the York Engineering Company, Limited. The consulting engineer is Sir Frederick Bramwell, Bart. The secretary (*pro tem.*) is Mr. Robert Gordon, and the offices are situate at 2, Tokenhouse-buildings, King's Arms-yard, E.C. The object of the Company is to acquire the British patents in respect of Elihu Thomson's inventions for the electric welding and working of metals. In America a foundry exists in which about 250 hands are employed in producing the machines. The prospectus contains a number of favourable reports from various firms who are using the machines. It is not proposed to sell the machines right out, but they are to be delivered for a specified sum, and a small royalty is to be paid to the Company for their use. It is estimated that in the United Kingdom there are sufficient works, trades, &c., to create a great demand for electric welding machines, and that if only a small proportion of such works are supplied the profits from royalties alone will make a good return upon the capital of the present Company. The lists of application will close on or before to-morrow (Saturday).

ESTATES IMPROVEMENT COMPANY (LIMITED).—This Company was registered on August 20, 1891, with a capital of £25,000 in £100 shares. The objects are:—To acquire and develop lands and buildings in the County of Middlesex, to construct, maintain, improve, develop, and control electric power, heat, and light supply works, telephone works, &c. The regulations of Table A mainly apply.

GENERAL SAFE DEPOSIT SYNDICATE (LIMITED).—This Company was registered on August 22, 1891, with a capital of £5,000 in £10 shares. The objects of the Company are, amongst others, to carry on the business of mechanical and electrical engineers, safe manufacturers and dealers, locksmiths, &c. Registered without special articles. Office: 3, Pope's Head-alley, Cornhill, London, E.C.

GEORGE SPENCER, MOULTON AND COMPANY (LIMITED).—This Company was registered on August 22, 1891, with a capital of £233,130 in £10 shares, by F. J. Abbott, 40 and 42, Queen Victoria-street, E C. The objects are:—To acquire and take over as going concerns; first, the business of india-rubber manufacturers carried on by Stephen Moulton and Co., at Bradford, Wiltshire, and second, the business of india-rubber spring manufacturers, carried on by George Spencer and Co., at 77, Cannon-street, E.C., and 81, Southwark-street, S.E., and to carry on the business of india-rubber and gutta-percha manufacturers. The first Directors are H. Moulton, J. Moulton, E. S. Stidolph, A. G. Spencer, A. Spencer, and F. Spencer.

LLANBRADACH LAND AND BUILDING INVESTMENT COMPANY (LIMITED).—This Company was registered on August 24, 1891, with a capital of £10,000 in £10 shares, by Jordan and Sons, 120, Chancery-lane, W.C. It intends to acquire and develop property of all kinds. To construct, maintain, work, and control gas and water works, roads, tramways electric power, heat and light supply works, telephone works, &c. Registered without special articles. Office: Court House-street, Pontypridd.

MARTINY (LIMITED).—This Company was registered on August 20, 1891, with a capital of £200,000, divided into 40,000 ordinary and 10,000 Five per Cent. Preference Shares of £4 each, by Michael Abrahams, Sons, and Co., 8, Old Jewry, E.C. The objects are:—To acquire and take over as a going concern the business of The New Asbestos Company (Limited), upon the terms of an unregistered agreement dated July 2, 1891, between The New Asbestos Company (Limited) of the one part, and John Simpson of the other part. To acquire and take over the business of Messrs. Martiny and Co., of Paris, india-rubber, gutta-percha, and cable manufacturers, upon the terms of an unregistered agreement, dated June 19, 1891, between Martiny and Co., of the one part, and J. Simpson, for this Company, of the other part. To carry on the above businesses in all their respective branches. To manufacture among other articles, telegraph and other cables and wires, india-rubber, gutta-percha, and asbestos goods of every description. The number of Directors is not to be less than three nor more than seven. Qualification, £1,000 shares or stock. £900, with an additional £100 for the chairman, will be divided annually among the Directors as remuneration, together with a sum equal to one-tenth of the profits after the payment of the preferential dividend and 6 per cent. on the ordinary shares.

OXFORD ELECTRIC COMPANY (LIMITED).—This Company was registered on August 24, 1891, with a capital of £100,000 in £5 shares, by Walter Webb and Co., 23, Queen Victoria-street, E.C. The objects are:—To carry on in the City of Oxford and neighbourhood the business of an Electric Lighting Company in all its branches. To produce and supply electricity and electrical energy for the purposes of light, heat, or motive power. To enter into an agreement with the Electric Construction Corporation (Limited). To manufacture, sell, deal in, and let out for hire, engines, machinery, wires, lamps, instruments, and apparatus of all kinds for the production, storage, supply, measurement, use, or application of electricity. The subscribers are:—

	Shares.
J. Irving Courtenay, M.A., Trinity College, Oxford	1
H. Musgrove, Seymour Villa, Anerley	1
George Offor, 4, Great Winchester-street, E.C.	1
J. Ebbsmith, 86, St. James's-street, S.W.	1
R. Buckell, 32, Beaumont-street, Oxford (Mayor of Oxford)	1
T. Lucas, North Land, Oxford (Sheriff)	1
T. Green, 25, Leckford-road, Oxford (Alderman)	1

The number of Directors is not to be less than three nor more than seven, the first to be appointed by the subscribers. Qualification, £250. The Company in general meeting will determine remuneration.

BRITISH ELECTRO-CHEMICAL AGENCY (LIMITED).—The registered office of this Company is situate at Worcester House, Walbrook, London, E.C.

ENERGY GAS, ELECTRIC LIGHTING AND POWER COMPANY (LIMITED).—The registered office of this Company is situated at 5, Chancery Lane London, W.C.

MUNICIPAL ELECTRIC LIGHT AND POWER CORPORATION (LIMITED).—The annual return of this Company, made up to December 31, 1890, was filed on August 18, 1891. The Company was registered on June 5, 1889, with a capital of £25,000, divided into 2,490 ordinary shares of £10 each and 100 founders' shares of £1 each. 37 ordinary and 30 founders' shares have been taken up; upon all of the ordinary the full amount has been called. The 30 founders are considered as fully paid. The calls paid amount to £210, and unpaid to £160. The annual return, made up to August 14, 1891, was filed on August 18, 1891. The same number of shares are taken up, and all the calls are paid, amounting to £370. Office: 33, Old Broad-street, E.C.

UNION ELECTRICAL POWER AND LIGHT COMPANY (LIMITED).—In the High Court of Justice, Chancery Division, Mr. Justice Chitty (at Chambers). Upon the application of Harrington E. Broad, the official liquidator of the above-named Company, it was ordered that since the affairs of the Company had been completely wound up except the application of £217. 9s., the solicitors of the Company, Messrs. Linklater and Co., of 2, Bond-court, Walbrook, should receive £157. 13s., 2d., being the amount o their taxed costs, and that the liquidator be at liberty to retain the remainder (£59. 15s. 10d.) in full discharge for all his claims. It was also

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ordered that the said Company be dissolved as from June 26, 1891. This Company was registered on December 6, 1886, with a capital of £500,000, in £5 shares, which capital was, by a special resolution passed March 4, 1887, and confirmed March 22, 1887, reduced to £100,000, in £5 shares. Since its incorporation only 70 shares have been taken up, nothing being paid thereon.

With reference to a note under this heading in our last issue, Messrs. Laurence. Scott and Co. write us:—"We notice in your last issue, under the heading of New Companies, Statutory Returns, &c., an abstract of agreement made between us and the Ipswich Electricity Supply Company (Limited). This abstract would lead your readers to suppose that we have disposed of our business, which is not the case. The agreement referred to does not in any way interfere with our regular business, but was made simply to facilitate the development of the supply of electricity in Ipswich by transferring the existing supply station from us to the Ipswich Electricity Supply Company, in which company we retain a substantial interest. It will be seen, therefore, that the agreement in question concerns the Ipswich Supply Company only."

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the past week were £4,186.

CITY AND SOUTH LONDON RAILWAY COMPANY.—The traffic receipts of this Company for the week ended August 23rd amounted to £728.

LONDON PLATINO-BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The half-yearly coupon on the Six per Cent. Debentures of this Company, due on September 1st, will be paid at the banking house of Messrs. Glyn, Mills, and Co., Lombard-street, E.C.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended August 21st, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company were £2,812.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, August 19.		Price Wednesday, August 26.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending August 26.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS.								
£1,300,980	Stock	12/0	Anglo-American	45½	46½	46½	47½	5 15 9	Jan., Apr., July, Oct.	47⅞	46½
£2,849,510	Stock	24/0	Do. Preferred	84	85	85½	86½	6 7 2	" "	86½	84⅞
£2,849,510	Stock	5/0	Do. Deferred	10¼	10⅜	11	11½	..	.. ..	11¼	10⅜
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99	102	99	102	3 18 5	January and July ..	99⅝	99½
150,000	£10	5/0	Brazilian Submarine	11⅜	12½	11⅜	12½	6 18 9	Mar., June, Oct., Dec.	12⅛	11½
£69,200	£100	5%	Do. 5 per Cent. Bonds	99	102	99	102	4 18 0	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103	107	103	107	4 13 6	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	105	109	107	109	6 3 10	April and October ..	108½	108½
16,000	10	8/0	Cuba Submarine	10	11	10	11	7 5 6	February and August	10⅜	..
6,000	10	10%	Do. Preference 10%	16½	17½	16½	17½	5 14 3	" "	..	..
12 931	5	3/2½	Direct Spanish (£4 paid)	3⅜	4½	3⅜	4½	6 11 9	April and October..	3⅛	..
6,000	5	10%	Do. Preference 10%	9½	10½	9½	10½	4 15 3	" "	..	..
60,710	20	3/6	Direct United States	10⅜	10⅝	10⅜	11	6 7 3	Jan., Apr., July, Oct.	11	10⅜
400,000	10	5/6	Eastern	14½	14⅝	14½	14½	4 9 8	" "	14½	14⅛
70,000	10	6%	Do. 6 per Cent. Preference	15	15½	15	15½	3 17 5	" "	15⅜	15
£1,250,000	Stock	6%	Do. 4 per Cent. Mort. Debenture Stock	107	110	107	110	3 12 9	May and November	108½	108
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	106	109	107	110	4 10 11	February & August	..	..
250,000	10	2/6	Eastern Extension	14⅝	14⅞	14⅜	15	4 13 4	Jan., Apr., July, Oct.	15	14⅜
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock	104	107	105	108	3 14 1	February & August	107	..
£85,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103	106	104	107	4 13 6	January and July ..	104	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	102	105	102	105	4 15 3	" "	103	102
180,227	10	4/6	Globe Telegraph and Trust	9½	9⅝	9½	9⅝	5 7 8	Jan., Apr., July, Oct.	9⅝	9⅛
180,042	10	6%	Do. 6 per Cent. Preference	14⅝	15⅜	14⅝	15⅜	3 19 4	" "	15⅜	14⅜
150,000	10	5/0	Great Northern	18⅜	19¼	18⅜	19¼	4 8 4	Jan., April, and July	18⅜	..
£ 20,000	100	5%	Do. 5 per Cent. Debentures, 1883	106	109	106	109	4 11 9	March & September	..	..
17,000	25	37/6	Indo-European	41	43	41	43	5 15 3	May and November	42¾	..
38,348	10	5/0	London latino-Brazilian	6½	7⅛	6½	7⅛	6 0 0	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	107	110	107	110	5 9 1	March & September	..	..
9,000	8	4/0	Reuter's	8	8½	8	8½	4 14 1	April and October..	..	..
3,381	£100 Cert.	£1	Submarine Cables Trust 6%	117	121	117	121	4 19 2	" "	..	..
15,609	10	6/0	West African Telegraph	8	9	8	9	5 11 1	January and July ..	..	..
£281,400	100	5%	Do. 5 per Cent. Debentures	96	99	97	100	5 0 0	March & September	98½	..
30,000	10	2/0	West Coast of America	2½	3½	2½	3½	..	January and July ..	3½	3
£150,000	100	8%	Do. Debentures 8% 1902	97	102	97	102	7 16 10	June and December	..	..
88,321	10	9d.	West India and Panama	1⅞	2⅛	1⅞	2⅛	..	..	2	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10	10½	10	10½	5 14 3	May and November	..	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9	10	9	10	6 0 0	" "	..	..
61,683	15	9/0	Western and Brazilian	10⅜	11½	10⅜	11½	6 13 4	" "	11½	10⅜
30,364	7½	1/6	Do 5 per Cent. Cumulative Preferred	6½	7	6½	7	5 7 3	—	7	6¼
30,364	7½	7/6	Do. 5 per Cent. Deferred	4¼	4⅜	4½	4⅝	..	..	4⅜	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	102	105	102	105	5 14 3	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	101	104	102	105	5 14 3	" "	104½	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117	122	117	122	5 14 9	May and November	..	..
£ 73,100	£100	6%	Do, 6 per Cent. Sterling Bonds	101	105	101	105	5 14 3	March & September	..	..
			TELEPHONES.								
224,850	14/0	0/5½	Consolidated Telephone Const. & Maintenance	⅜	½	⅜	½	..	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid)	1⅛	1⅜	1⅛	1⅜	6 3 11	Yearly	..	..
438,984	5	3/6	National	4⅛	4⅜	4⅛	4⅜	6 3 1	June and December	4⅞	4½
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½	13½	12½	13½	4 8 11	" "	..	..
15,000	10	6%	Do 6 per Cent. Cumulative 2nd Pref. (£8 pd)	12½	13	12½	13	3 14 1	" "	..	..
350,000	£10	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd)	105	107	105	107	4 4 1	..	106½	105⅞
58,000	5	1/0	United River Plate	1½	2½	1½	2½	..	January and July ..	..	..
£146,370	tock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 8	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
1,000	£50	..	City of London Electric Lighting (£50 fully paid)	60	62	60	62	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	4½	5	4½	5	..	..	..	..
5,322	£5	..	House to House Electric	4½	5	4½	5	..	..	..	..
30,000	£5	..	Liverpool Electric Supply (£3 paid)	2⅜	2⅝	2⅜	2⅝	3 13 1	..	..	..
111,000	5	..	London Electric Supply	2	2¼	2	2¼	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	9½	10	9⅝	10½	..	..	10	9⅝
7,730	£5	3/6	St. James' and Pall Mall	6⅞	7¼	6⅞	7¼	—	..	..	..
..	..	7%	Do. 7% Preference	4¼	4⅜	4¼	4⅜	—	..	4⅜	4¼
42,853	5	..	Westminster Electric Supply (£5 paid)	5	5½	5	5½	..	..	5⅛	5¼
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978		..	Brush Electrical Engineering	2⅝	2⅞	2⅝	2⅝	..	..	..	..
69,996		6%	Do. 6 per Cent. Preference	1⅞	2	1⅞	2	6 0 0	June and December	1⅛	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	4	5	4	5	7 0 0	January and July ..	..	..
17,139	5	..	Edison and Swan United	..	..	..	..	..	—	..	..
45,000	10	6%	Electric Construction	3½	4½	3½	4½	..	—	3⅛	..
70,000	2	10/0	Elmore's Patent Copper Depositing	3⅜	3⅝	2⅜	2⅝	..	—	3¼	3⅛
20,000	5	..	Fowler-Waring Cables (£4 paid)	2	3	2	3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	19	20	19	20	5 0 0	February & August	19⅝	19⅜
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	104	106	104	106	4 4 11	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	7½	8½	7½	8½	11 15 3	..	..	..
11,334	£10	5/0	Do. Preference	9½	9⅝	9½	9⅝	8 4 1	..	..	..
78,949	5	2/1½	Swan United (£3. 10s. paid)	4½	5	4½	5	6 19 10	May and November	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	43	45	42	44	5 9 3	March and July.....	43½	42
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101	104	101	104	4 16 2	January and July ..	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£2. 10s. paid)	2½	2⅝	2½	2⅝	..	..	..	..
—	£5	..	Do. Preference (fully paid)	3¾	4	3¾	4	..	..	..	..
			RAILWAYS.								
50,000	£10	..	City and South London Railway	3	5	3	5	—	—	..	..

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NOTES.

The Electrical Standards Committee, which was appointed by the Board of Trade in December last, practically concluded its labours on July 23rd, when the Report, published last week, embodying the resolutions which had been arrived at was finally agreed to and passed. It now only remains for the Committee to receive and adopt the specification with regard to the preparation and use of the Clark cell, and to approve of the specifications referred to in the schedule of the Draft Order in Council, appended to the Report. The Clark cell was the subject of considerable discussion, although the task of drawing up the specification relating to it was, at an early stage in the proceedings, delegated to a Sub-Committee, composed of Lord Rayleigh, Mr. R. T. Glazebrook, and Major Cardew, in whose hands it is still left. However satisfactory a standard the Clark cell may be when constructed with scrupulous care by skilled and experienced individuals, and used by them with due precautions, it apparently leaves something to be desired when made and used by the "average man," in accordance with concise written instructions.

If anyone was apprehensive lest the consultations of the Committee should result in the legalisation of "abstractions," the schedule appended to the Draft Order in Council, which, together with the Report, will be found in another column, will be eminently consolatory. The ohm is no longer "1,000,000,000 in terms of the centimetre and the second of time," but "the resistance offered by the coil of metal marked . . . . ." Similarly the ampere is that current which when passed through a certain marked instrument exerts a certain electromagnetic effort, balanced at Westminster by a certain marked platinum weight, and in much the same way the volt also develops into an unmistakable "concrete."

Although the resolutions, as finally agreed to, do not differ in any material respect from those contained in the Draft Memorandum, published in *The Electrician* of February 13th, much labour was expended on verbal refinements, with the laudable view of attaining something like mathematical accuracy of definition. In the case of Resolution No. 13, or, as it then was, Resolution No. 11, the strivings after the ideal were particularly painful.

As originally drafted, the clause ran as follows:—"That the standard of electrical pressure should be denominated the volt, being the pressure which, if steadily applied, will produce a current of one ampere in a conductor whose resistance is one ohm, *provided that the current is doing no work.*" Around the words we have italicised there immediately arose a remarkably energetic controversy. Mr. Glazebrook thought the adjective "external" should be interpolated. On the other hand, Sir William Thomson, Lord Rayleigh, and Mr. Preece, were for lopping off the offending member. The Electrical Adviser to the Board of Trade advocated the retention of the final sentence; the resistance might, he said, be the armature of a dynamo, a chemical solution, a thermo-electric couple, or what not. Sir William Thomson was prepared to defend the clause, without the reference to work, before the whole world, "Taking all the text books that have ever been written, taking all the definitions of ohm, separating them from deposits of polarisation, this stands unambiguous," was his emphatic declaration. Nevertheless, the Electrical Adviser to the Board of Trade ventured to reopen the question at the next meeting of the Committee. With all respect to Sir William Thomson, he "did not much like no allusion being made to the possibility of there being an electromotive force." "Homogeneous metallic conductor at rest in an unvarying magnetic field" was thereupon suggested. This proposal immediately started a discussion on another point, which continued, notwithstanding Lord Rayleigh's remark that "if you want to state everything you will have to write half a treatise on it." Finally, the Committee gave up the attempt, and left the resolution as it now stands, it being, in Prof. Carey Foster's opinion, "perfectly intelligible with a little common sense applied to it."

The only resolutions which have been added to the first draft are Nos. 8, 15, and 16. Two more were, however, brought forward, one defining the "volt × ampere," and christening it the "watt;" the other defining the Board of Trade unit of electrical supply, and labelling it the *bot*. Not meeting with general acceptance, these clauses were cheerfully withdrawn by their originator.

In a letter to *The Times* of August 20th, the Duke of Marlborough, who has already on several occasions raised the question in the House of Lords, has a good deal to say about the telephone. He announces that "a new company, which possesses a licence from the Postmaster-General, is about to promote a Bill before Parliament next Session with the object of establishing a complete twin-wire telephone service for the whole of London on the basis of a £10 a year rental." We

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sincerely trust that this promising concern has good technical advisers and ample financial support behind it, for the task of ousting the National Company from the metropolis will, indeed, be no light one. Some little time ago we ventured to hope that either the metropolitan rates would come down, or the efficiency of the service would go up, but here we are led to expect both boons simultaneously. Meanwhile, to quote Mr. FAITHFULL BEGG's letter to *The Times* of yesterday, some may be of opinion that "the best possible thing to be done will be to let the proposed new Company try it and give us the benefit of their experience."

MR. BEGG, whose letter will be found elsewhere in our columns, takes up the cudgels on behalf of the National Company, and certainly succeeds in making out a strong case for it. All that concerns the London public, however, is how best to secure an efficient telephone service at a reasonable rate; and at first glance, we must confess we do not see why in the present instance order should be evolved out of the chaos of competition. If, after a proper period has elapsed, the National Company should fail to rise to the occasion, perhaps the strong arm of the Post Office would prove a more effective weapon than joint-stock competition.

THE *Philosophical Magazine* for August contains an interesting Paper by Prof. PERRY, detailing the results of many laborious calculations with reference to the behaviour of transformers. As was necessarily the case, the transformer studied was of the pure mathematical type, and Prof. PERRY excuses the assumptions made of constant permeability, and the absence of losses due to hysteresis, and eddy current losses, on the grounds that the laws of a transformer are not yet known even under these conditions, and that if these laws are found out it will be possible, by comparing the theoretical results with those obtained experimentally with actual transformers, to obtain useful information concerning the influence of the neglected phenomena. This process may be objected to on account of the impossible efficiency, sometimes as high as 99 per cent., which such a transformer possesses. On the other hand, it must be admitted that the assumptions made by various writers, in order to make their calculations fit with actual results, have often been somewhat reckless, while the practical difficulties in the way of accurate testing are far too great for the experiments hitherto published to be reliable in detail. The numerous tables of calculations accompanying the Paper contain results which no experiment could have detected. For instance, angles of lag are given accurately to the sixth figure, whereas lags of from 175deg. to 180deg. could hardly be distinguished from each other by measuring instruments.

THE most important results of the investigation are those referring to the influence of magnetic leakage. The effect of such leakage is to considerably increase the angle of lag between the primary volts and amperes. The efficiency of the transformer is, however, affected but little. If there is no magnetic leakage the product of primary volts and amperes is very approximately equal to the power supplied in watts for nearly the whole range of load for which the transformer is intended. If, however, magnetic leakage occurs, this is by no means the case, and the product is greater than the true watts, even for heavy loads.

IT has been somewhat longer on the way than we anticipated, but it is satisfactory to find that nevertheless it has at last arrived. We refer to the enunciation in the daily Press of the theory of the possibility if not probability of the existence of some hidden connection between the late thundery weather and the recent development of electric lighting in London. Can any clever meteorologist explain the phenomenon which some persons have already attributed to the electric light, says a contributor to the *Daily Graphic* of August 22nd? "Without committing oneself to any wild theory, which may be easily started by the ignorant, one may be allowed to question whether, even among scientific men, any idea can be formed of the consequences of permeating London with the electric fluid as it is at the present moment. This permeation is daily increasing, and in a few years' time the whole of London will have wires running in every direction, on a system as elaborate as the nerves in the human body. Experts should be able to tell us whether there lurks any danger in this universal wiring."

Shoreditch Vestry.—This Vestry has decided to obtain power to supply electricity within the parish of Shoreditch for public and private purposes.

New Books.—Messrs. Whittaker and Co. are about to bring out a book by Mr. W. Perren Maycock, entitled "A First Book of Electricity and Magnetism."

The Telephone in the Field.—The headquarters of the four army corps now manœuvering in the vicinity of Bar-sur-Aube are all connected by telephone, the utility of which is to be thoroughly tested.

Telephone Line between Leipzig and Dresden.—The telephone line between Leipzig and Dresden (80 miles) was opened on the 26th ult. The charge made is one shilling for three minutes' conversation.

University College of North Wales.—Prof. Andrew Gray will begin, in October next, a systematic course of instruction in electrical measurement and practical electricity at this college. For further particulars see our advertisement columns.

Train Lighting in France.—It is reported that, after several successful experiments with the electric lighting of the trains on the Paris, Lyons, and Mediterranean line, the Company have definitely decided to light the whole of their trains in that manner.

Personal.—Mr. J. Edward Waller, who has for many years been associated with Mr. Joseph Kincaid as his manager, has entered into partnership with Mr. Edward Manville, consulting electrical engineer. Messrs. Waller and Manville will carry on business at 39, Victoria-street.

Guernsey Electric Railway.—As the Channel Islands are outside the jurisdiction of the Board of Trade, the supervision of the erection of this line is being carried out by the Special States Committee, who have appointed Mr. Bernard Drake as their electrical adviser.

Manchester.—The City Council have passed a resolution to apply to the Local Government Board for sanction to borrow £150,000 for Corporation electric lighting scheme. Sir John Harwood stated that the whole arrangements had been placed in Dr. Hopkinson's hands.

Institution of Electrical Engineers.—At a "special general meeting of members only," held at the offices of the Institution, on Monday last, Mr. Alexander Siemens, vice-president, in the chair, the special resolution passed at the meeting of August 13th was unanimously confirmed.

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Technical Education.—We understand that the Professorship of Physics at Aberystwith College is now vacant, owing to the resignation of Prof. D. E. Jones, who has accepted an appointment as Organising Secretary or Director of Technical Instruction to the Staffordshire County Council.

Obituary.—We regret to have to record the death of one of the members of the Old Students' Association, at the age of 22. Mr. George T. S. Muller, who was well known to most of the members of this association, was drowned at Hampstead bathing-pond on Friday morning, August 28th, being suddenly seized with cramp.

Copper.—According to Messrs. H. H. Merton and Co., the total stocks on the 31st ult. amounted to 58,829 tons, as compared with 57,782 tons on the 31st of July and 69,959 tons a year ago. Deliveries during August, as during July, have been on a low scale, amounting only to 8,306 tons, as against an average of 10,672 tons per month for the preceding eleven months.

Telegraphic Communication with Mashonaland.—The telegraph has been continued from Fort Tuli to Fort Victoria, and one month ago it had been extended 60 miles north of the latter place, or for nearly 300 miles north of the former station. The wire is carried on iron poles as far as Fort Tuli, and the British South Africa Company has expended as much as £60,000 in establishing telegraphic communication with Mashonaland, which is thus brought within five hours, telegraphically, of London.

Conservatory Lighting.—The Société Electricité et Hydraulique of Charleroi has obtained the contract for lighting the conservatories attached to the King of the Belgians' palace at Laerkin. The palm houses were experimentally illuminated by electricity in the spring, and the effects produced were so charming that it was immediately decided to light up all the conservatories in the same way. About 1,000 incandescents and 40 arcs will be required and the three-wire system will be used.

Telegraphic Communication with Brazil and the River Plate.—The Western and Brazilian Telegraph Company announces that, under the arrangements recently concluded with the Brazilian Government, its system has been strengthened by loop cables being laid from Pernambuco to Bahia, Bahia to Rio de Janeiro, and Rio de Janeiro to Santos, thus giving a complete duplicate service of cables from London to Pernambuco, Bahia, Rio de Janeiro, and Santos, in Brazil, and thence a direct cable for the service with the River Plate. These new cables will afford greatly increased facilities in the working of the traffic between South America and Europe.

The Electric Lighting Accident on the Great Northern Railway.—The accident in connection with the electric lighting apparatus, which occurred on Thursday morning last week, to the 9:17 Great Northern train from Barnet to Moorgate-street, was scarcely of as alarming a character as the daily papers would have us believe. The fire was a very small affair and caused little or no damage. It arose through a slight accumulation of dust from the brushes, and this heating caused the wood covering to get charred. No electrical attendant was travelling with the train, as they only travel occasionally for the purpose of oiling and cleaning.

The Growth of Electric Lighting in London.—The able article on this subject which appeared in *The Times* for August 19th has drawn several letters from well-known electrical engineers. Mr. R. E. Crompton contributed a letter a column long to *The Times* of Saturday last, in which he maintained his familiar thesis that the Electric Lighting Act of 1882 cannot be accepted as a blessing in disguise, because it killed unsound speculation and prevented crude work. Mr. Crompton states that he was as well able to design a low-pressure station in 1883 as in 1891, and that *bonâ fide* investors were frightened at the same time that speculation was crushed out.

The Telegraph in Morocco.—According to a Reuter's telegram from Tangier, the Angera tribe, in the vicinity of Tangier, have stubbornly opposed the erection of telegraph posts, by Spaniards, within their territory. The Spanish Minister to Morocco, therefore, made strong representations to the Minister for Foreign Affairs against the hostile attitude of the people, in consequence of which the Moorish Minister immediately despatched a courier to the Governor of Tetuan, under whose jurisdiction the Angera tribe is placed, but without any satisfactory result, the Sheikhs of Angera refusing to obey the Governor's orders.

Extension of the Clermont-Ferrand Electric Railway.—Permission has been given to prolong the electric railway connecting Clermont-Ferrand with Royat-les-Bains (4½ miles distant) to the summit of the Puy-de-Dôme, which is 5,000ft. above the level of the sea. The extension will be completed in about eighteen months, and will comprise examples of the ordinary adhesive system of traction, as well as of the rack and funicular methods. The line between Clermont-Ferrand and Royat has been in successful operation for some little time past. The current is supplied at a pressure of 300 volts, an overhead conductor and rail return being employed. The conductor is a slotted copper tube, inside which runs a sliding contact, consisting of a string of bronze balls connected together by a piece of wire. Each car carries 50 passengers, and is worked through Vaucanson chain gearing by a 40 H.P. motor.

Thunderstorms.—On Friday, the 21st ult., at Port-Laing, near Inverkeithing, a man was struck by lightning while sheltering under a tree, and was killed on the spot. Severe storms, during which much damage to property was caused by lightning, occurred last week in Scotland, the Midlands, the Western Counties, and the South. On the 26th ult. a terrible thunderstorm passed over the Goerz district. At the village of Dobra a woman, who was standing by her fireside, was struck by lightning and killed. At Tualis, on the other side of the Italian frontier, the lightning struck a church during mass time, when it was filled with worshippers. A scene of the utmost confusion and alarm ensued. When calm had been restored it was found that three women had been killed. At Pian a huntsman was struck dead on the hills, and four of his comrades were temporarily paralysed. In the early hours of Tuesday last many houses were set on fire by lightning in the Departments of Saone-et-Loire and of Isère. Three houses were destroyed by fire at Sergenave, and two at Aslay. During a storm near Montbrisson, a farm labourer of Chazelles was standing with his family round a wood fire, when the house was struck by lightning, and the mother and two children were killed.

The Crystal Palace Electrical Exhibition.—The Crystal Palace Electrical Exhibition has now received the sanction of the Board of Trade, and is duly certified as an International Exhibition, under the provisions of the Patents, Designs, and Trade Marks Act, 1883. This Act provides for the publication of any description of the invention during the period of the Exhibition, or the use of the invention for the purpose of the Exhibition, or its use by any person elsewhere without the privity or consent of the inventor, without prejudicing the right of the inventor to apply for and obtain provisional protection, and a patent within six months of the opening of the Exhibition. The right of application for registration of designs is also protected by this Act for a period of six months from the opening of the Exhibition. The exhibits of Her Majesty's Government will include historical telegraphic and electrical apparatus, instruments, and appliances, as well as the modern apparatus and instruments now in use in the Postal Telegraph Department. This exhibit will be arranged under the direction of Mr. W. H. Preece.

The New Central Telegraph Office at Brussels.—The Brussels Post Office authorities are just now busily engaged in preparing the new Hôtel des Postes in the Place de la Monnaie. In the telegraph department the telephone will figure largely. Specially-constructed *cabines* will be reserved for those who wish to hold telephonic communications with Paris, Antwerp, Amsterdam, and other important towns, and a numerous corps of *employés* will be detailed for the sole purpose of transmitting by telephone, to such subscribers as may care to pay for the privilege, the contents of telegrams addressed to them. For the past six months experiments have been in progress for the purpose of testing "sounder," with the result that it has been decided to substitute it, as far as possible and as soon as possible, for the Hughes and Morse apparatus. The total number of instruments about to be installed in the new central office is 160, viz., 32 Hughes, 100 Morse, and 28 sounder instruments. The number of operators will amount to about 270. The new

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Hôtel des Postes will be lighted throughout by electricity, and will be connected by pneumatic tube to the Bourse. In future all telegraph material is to be obtained from Belgian firms.

Electric Lighting in Auckland, N.Z.—At a special meeting of the Auckland City Council, convened to consider the Auckland Electric Lighting Bill, a letter which had been received from Mr. D. De Castro on the subject was read. Mr. De Castro asked that the matter should be brought before the Council, and some assent or refusal obtained from them in regard to a system of overhead wires being introduced into Auckland. This was to enable him to bring the Bill properly before Parliament, and he would not dream of proceeding with it unless he had some assurance that the Council would not object to overhead wires. The Bill was drawn on the lines of the private Acts, which he said were granted by the score in England every year lately. If the underground system would not pay in Melbourne it would not pay in Auckland, and the thing amounted to overhead electric lighting or no electric lighting at all. After consideration, it was unanimously resolved:—"That the Council refuses its consent to the Auckland Electric Lighting Bill because, among other objections, it vests the control of the undertaking in an outside Board, in the appointment of which the Council has no voice, and that the Mayor be instructed to take such steps as he may deem necessary to oppose the passing of the Bill."

Electrostatic Capacity and Electric Light Cables.—If it is not permissible, says a correspondent in the *Electrical Engineer* of New York, from considerations of safety to life, to operate high-tension continuous currents on grounded circuits, with, or without, static capacity, is it safe, for similar reasons, to operate high-tension alternating currents on circuits of large electrostatic capacity, even though their insulation be very perfect? I recently laid two submarine cables, half-a-mile in length, whose insulation resistance was 2,000 megohms, but whose static capacity was very large, due to the high specific inductive capacity of the compound used as insulation. The cables were connected to an alternating current dynamo giving a pressure of 1,100 volts and a frequency of 125 per second, supplying current for the lighting of a small village, which could only be conveniently reached by cable. In order to test the effect of the cable's capacity, I connected one end of the primary of a transformer to one wire leading from the dynamo, and grounded the other end of the primary, when a lamp attached to the secondaries immediately lighted up to nearly full candle power. I considered this due to the electrostatic capacity of the cables, and believe it would be very disastrous, indeed, to the one who would be unfortunate enough to get himself in a position similar to the primary of the converter. Perhaps the matter may be of interest to the New York Board of Electrical Control, as so many lead-covered cables are being used in New York at present.

Chagford (S. Devon.)—An electric lighting station has been erected at Chagford, in an old woollen factory about half to three-quarter mile outside the town, where a water wheel was already fixed. At one end of the room there is a countershaft. The wheel is a 14ft. by 14ft. breast backshot, with ventilated buckets, making about eight revolutions a minute. The electrical plant consists of two 20-unit 2,000-volt Siemens alternators, running at 850 revolutions, excited from two shunt-wound Crompton dynamos. The mains consist of two lead-covered cables, $\frac{7}{16}$ B.W.G., manufactured by the Norwich Insulated Wire Company. The cable is laid underground in stout oak casing, tarred outside. A considerable part of the road had to be blasted before the cable could be laid. The 2,000-volt mains run to five distributing points, where transformers of the "Hedgehog" type are fixed. The distribution by low-pressure wires radiates from these points. The secondary wires are taken along the back of the housetops, so that from the road it is difficult to discover where the wires are run. The material was supplied by Crompton and Co., and the work was carried out under the direction of Mr. G. H. Reed, of Chagford. Trial runs of a few hours each have been made every night since Tuesday, 25th ult., with perfect success. Some 120 lights, representing 24 customers, were connected on the first night. This interesting little installation affords examples therefore of three of the very latest ideas, viz., sub-stations, "Hedgehog" transformers, and the use of water power. It also shows that a well-constructed water wheel will run perfectly steady for lighting purposes.

The Search Light at Iquique.—Mr. J. Acton Lomax, an electrical engineer, associated with Mr. W. Hoffmann, the Thomson-Houston agent in Chili, has, says the *Electrical Engineer* of New York, recently arrived in New York from the seat of hostilities. Being stationed at Iquique, he was called upon by the Congressionalists to furnish a light for an island about 1,000 yards from the shore. The first plan was to put eight 1,200 c.p. arcs inside a parabolic reflector, 6ft. in diameter and 8ft. in length. But the plant could not be got to work satisfactorily. They then borrowed from the engineer of the "Cochrane" one of the old mirrors from her search light. This they rigged up with one of the 1,200 c.p. lights, put the combination in a box and tried it near the dynamo house, getting steam for the engine from the fire brigade engine-house, where steam was always kept up. Next came the question of a circuit to the island. Finally this was fixed up. At this juncture the Congressionalists did not want to pay, whereupon the plant was shut down. Then one night the Presidential torpedo boat "Condell" ran into the bay, darted all round the shipping, sent off a torpedo, and "played the devil" generally. The Congressional party, in a great scare, paid for the plant, and it was set going. It was arranged that any of the Congressional launches, cruising about all the time, should show certain lights, whenever the beam of light caught them. At last the search light picked up two craft coming in together, showing no light whatever. These suspicious craft made no responsive signal, so the ray was kept steadily on them. Very soon they got tired of this exposure, turned around and made for the open sea. They were evidently Presidential torpedo launches. After this object lesson of its utility the light was kept going nightly.

The Changes of Voltaic Energy of Alloys during Fusion.—In the *Comptes-Rendus* for June 10, 1878, J. Regnauld observed that liquid gallium was electropositive to solid gallium in a neuter solution of gallous sulphate. In the *Phil. Mag.* for July, Dr. Gore describes some experiments, the object of which was to ascertain whether the change of physical state of an alloy from solid to liquid by fusion, and the large absorption of heat which then occurs, was attended by a correspondingly large increase of electromotive force, and whether the converse effect occurred during solidification. Three electrolytes were used, viz., one composed of one part by weight of absolute hydrochloric acid in 100 of water; a second, of one part of chloride of sodium and 100 of water; and a nearly saturated solution of that salt. On applying heat, the heated portion of the alloy became gradually electropositive to the cold portion up to its fusion point; and a more or less sudden increase of electromotive force occurred during the further heating of the alloy and the electrolyte up to the boiling point of the latter, and this sudden increase appeared to coincide in point of time with the melting of the alloy. Substantially the reverse of these phenomena happened after removing the flame. The following alloys were experimented with:—Bismuth 70 parts, lead 40, tin 20, and cadmium 15; bismuth 8 parts, lead 8, and tin 3. Experiments were also made with mercurial amalgams. In the case of an amalgam of one part cadmium and four parts of mercury, easily liquefied in boiling water, when it was heated and had become pasty, the current began to increase; but just previous to complete liquefaction the current suddenly and considerably decreased, and the liquid amalgam became electronegative to the solid one; the period of reversal was very brief, and on further heating the current suddenly increased to a slightly higher point than it was at previously. By repeated experiments with this amalgam it was found that the sudden decrease of current was greater with the freshly prepared substance than with that which had been remelted several times. The mixture of metals which produced the most sudden increases of current in these experiments were those which exhibited the most sudden liquefaction. The results of the experiments show that changes of voltaic energy may be used in the above manner to detect physical and chemical changes in metallic alloys.

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SKETCH OF THE PROCEEDINGS OF SECTION A OF THE BRITISH ASSOCIATION AT CARDIFF.

BY DR. OLIVER LODGE, F.R.S.

The unfortunate time of year selected for the Cardiff meeting was responsible for the absence of a good many of those whom we have grown accustomed to welcome at these annual gatherings; and letters of regret and explanation were numerous. The principal ingredient in the programme for this year was Astronomy, rather than Electricity; and although the communications to Section A maintained their usual high level, and represented scientific work of a very high order, it may be admitted at once that to electricians in the narrow sense they were not specially attractive or important. Under these circumstances it is evidently just as well that the idea of constituting an Electrical Section which has been several times mooted has not received much support. Understanding that the readers of *The Electrician* who were not present may nevertheless like some account of what went on in the Section I proceed to give a brief sketch as usual.

The President's address, after dealing with colour photography and one or two other discoveries of the year, advocated at some length the establishment of a National Physical observatory or laboratory for quantitative and long continued physical research; especially for the exact determination of such physical constants as are required for practical purposes, to maintain the various standards in a state fit for use, and to arrange for the comparison and certification of authorised copies. After pointing out the advantages and use of such a permanent national institution, an institution which France and Germany already possesses or are acquiring, the address lapsed into metaphysics, and became unworthy of further notice.

The first Paper on the list was one of great importance, by Prof. H. A. Newton, of Newhaven, in the United States, who is the greatest authority in the world on the subject of meteorites, and whose researches have done so much towards identifying comets with meteoric streams. He has been mathematically investigating the action of large planets, especially of Jupiter, on these small bodies as they pass within its range of attraction. A certain percentage are diverted from their natural parabolic orbit round the sun and swung into an elliptic orbit so that they become permanent members of the solar system, always thereafter revolving round the sun and receding from him to about the distance of Jupiter. A few, however, are affected still more seriously; they go so near Jupiter as to be caught and checked. Their prodigious rush, of a dozen or so miles a second, is taken out of them, and they are left quiescent in space; so that there is no help for them, they simply drop into the sun. All large planets thus feed the sun with meteors, but the number thus struck dead and dropped is not great; and only the larger planets are able to do it. The earth, for instance, is not able. By the time a meteorite reaches the earth it is flying with a speed of 26 miles a second, and in order that the earth may be able to wipe out this velocity by gravitative attraction, its centre must approach the meteor as close as 3,000 miles. Now it is impossible for the earth to get as near a body as this, for its own radius is 4,000 miles, hence the earth cannot act in the way just described. It may perturb a few and cause them to move in elliptic orbits, but its action is insignificant when compared with that of the giant planets Jupiter, Saturn, Uranus, and Neptune. All these planets have been the means of introducing a number of comets or meteoric streams into the solar system, which thereafter circled in elliptic orbits whose greatest distance (or aphelion) is usually something not very different from the distance of the planet which introduced them, though in a few cases it may be less.

Prof. George Forbes mentioned that he had already called attention to the fact that a number of cometary orbits ended at about the distance of a planet, and had shown that the position of Neptune could have been roughly estimated by this very method. He has also predicted the existence of two trans-Neptunian planets, by considering the aphelion of other cometary orbits, and has endeavoured to calculate the present position of one of those hypothetical planets next beyond Neptune. Since its distance is about double Neptune, it must be an excessively faint object, but modern processes of stellar photography ought to be able to detect it. If it exists it will show itself on the photographic plate as a slightly oval—not perfectly round—spot, by means of its proper motion; or if its speed is hardly enough for that, it can be detected by comparing two plates of the same part of the heavens taken on different dates.

Mr. Isaac Roberts, whose stellar photographs have been the admiration of all astronomers, rose in the meeting and said that he had now photographed that part of the heavens where Prof. Forbes had located his hypothetical planet, and had critically scrutinised all the plates of this region, except two, without finding any trace of it. Either the planet was on those two plates, which are shortly to be examined, or it does not exist.

If a planet should ever, by means of cometary disturbances, be discovered, it will be a beautiful instance of the progress which this department of astronomy has made, and of the perfection to which the study of those obscure bodies, the meteorites, is now attaining. The General Committee subsequently requested Prof. Newton to allow his Paper to be printed *in extenso* in the annual volume of the Association. It contains a quantity of solid mathematical work, and only a general account of a few of the results was attempted to be given before the section.

Mr. W. E. Wilson followed with an account of some interesting observations he is making on the radiation received from different parts of the sun's surface. To this purpose he has applied Mr. Boys' radio-micrometer, over the disc of which he allows a very large image of the sun to slowly transit; the motion of the spot of light reflected from the mirror of the instrument being recorded on a travelling sheet of sensitised paper. It will be remembered that the radio-micrometer is a microscopic thermopile and galvanometer in one, the thermopile circuit being a single loop of fine wire suspended in a strong magnetic field, after the fashion of the siphon recorder. It is enormously more sensitive than any other radiation indicator, it is also very quick in its response and very dead-beat in its motion. All these are immense advantages when it is applied to examine celestial objects. With it Mr. Boys has readily detected heat in the radiation of the moon, and shown how it varies according to the angle of incidence of sunlight on its surface, no heat being received from the unilluminated body of the moon itself. He has further tried to detect heat from the stars, but has found no perceptible trace from any of them. Mr. Wilson's curve of intensity from different parts of the sun shows how greatly absorption in the solar atmosphere modifies the radiation, so that from the limit we receive very much less heat than from the central portions. From the corona and general solar surroundings we appear to get no appreciable quantity. Prof. G. E. Hale, of Chicago, gave an account of the appearance of the H and K lines in the solar prominences as photographed by a Rowland's grating and powerful telescope. Some of the appearances and reversals were very extraordinary, but it remains to be proved that these are not due to peculiarities introduced by the photographic process.

The last communication on the first day was a long and valuable report, which had been drawn up by Mr. G. H. Bryan, of Cambridge, partly in conjunction with Dr. J. Larmor, at the request of the Section, at its Leeds meeting, and which the author now handed in. It relates to the present state of our knowledge of thermo-dynamics, especially the much debated and criticised "second law." The report will appear in the annual volume, and is one of those documents which the British Association most prides itself on occasionally inducing learned but secluded and modest students to indite. The labour of drawing up such critical and precise reports is very great, and the men competent to write them are naturally not numerous.

Friday opened with a mathematical note by Prof. Andrew Gray, of Bangor, with reference to the Faraday rotation of the plane of polarisation of light in a magnetic field. Sir W. Thomson had illustrated the matter by a chain of gyrostats, and shown how a rotation of some kind round the lines of force was essential to the explanation of the phenomenon. Prof. Gray now considers a chain of molecular magnets arranged along the lines

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of force, and applying to them Maxwell's electro-magnetic equations, obtains a differential equation for the propagation of radiation along the lines of force, which is the same as that obtained by Sir W. Thomson with the chain of small gyrostats, and which, therefore, gives the observed rotation of plan of polarisation in the same way. Dr. Larmor remarked that probably any kinetic theory would lead to the particular term in the differential equation, on which the rotation of the plan of polarisation depended. No theory but a kinetic one would serve to explain the phenomenon, but kinetic theories would only differ in the particular kind of rotation postulated, whether material, etherial, or vaguely magnetic.

The present writer then gave a preliminary account of some experiments he is making to ascertain the effect of a rapidly moving body on the ether in its neighbourhood. It has long been a question whether the earth, for instance, moved freely through the ether without disturbing it in any way, or whether it dragged some of the ether with it. He proposes to attack the question by direct experiment, and to this end sends a beam of light, split into two equal portions, half of it with, and half of it against, the motion of a rapidly revolving disc or pair of discs. The two beams of light are then brought together and allowed to interfere. The observation consists in showing whether the system of interference bands shift their position when the discs are set into rapid rotation. If they do, it shows that one-half the light is accelerated, and the other half retarded, by the action of moving matter in its immediate neighbourhood. The discs selected are a pair of plates of hammered Sheffield steel, one yard in diameter, clamped together, and mounted on a vertical axle, which consists partly of a Mather and Platt "Manchester" dynamo, set up on end. The whole is supported by a strong cast-iron frame, and is bolted to masonry. A carbon block rheostat, by Rousseau, of Finsbury, is in circuit with the armature, and enables the speed to be regulated by varying the current supplied by a storage battery. The speed so far obtained is about 1,500 revolutions a minute, and the light has been passed several times round, each way, in the space between the discs. A pulley on the axle serves for a brake, and a syren disc above enables the speed to be quickly estimated. So far as experiments have yet gone, it may be asserted that the velocity of light is not affected in the neighbourhood of moving matter by so much as one-thirtieth of the velocity of the matter. But this result is quite preliminary, and it will be some time before the investigation is concluded.

Prof. Horace Lamb and several members expressed some interest in the apparatus, and in the question to be settled by it. Dr. Johnstone Stoney doubted whether the discs could hope to move the ether much, when the much larger mass of the earth itself might be effective in keeping it still; and Prof. Osborne Reynolds warned the experimenter of the danger arising from the rapidly whirling steel discs, pointing out that though to simple traction a tenacity of 67 tons per square inch might be attained, yet the conditions of surface strain in both directions to which the discs were subjected were very different, and not much was known about them. In this connection it may be interesting to remark how enormous centrifugal force may be compared with any intensity of gravity met with anywhere in the solar system. For instance, if a pound mass were put into a hollow drum, one foot in radius, spinning 100 times a second, it would fly up against the side, and press on it with a force of four tons weight. No wonder that cream is rapidly produced in milk-whirlers, which are often driven much faster than this.

Dr. J. Larmor next gave a general account of some mathematical investigation of the theory of electric radiation, starting from a Hertz vibrator as source. He did not say very much about his methods or results, but he found that reflecting surfaces behaved very differently to waves of great and waves of small length. Waves of great length, say much longer than a centimetre, are reflected by all conductors about equally well, without regard to small differences in their conductivity, without much regard to the substance that is. But very short waves, say much shorter than a centimetre, experience an effect due to the conductivity of the reflecting substance; and accordingly waves of light, so small as to be visible, feel every difference in the state of polish of a surface as well as in the material of which it is made.

Prof. D. E. Jones, of Aberystwith, described some experiments he had been recently making in Prof. Hertz's laboratory at Bonn, with the object of observing the rate of propagation and the rate of damping out of waves along wires. He does it by inserting a thermo-couple in the course of the wire, so that electric oscillation set up in the wire shall surge through it and heat it perceptibly. If the couple is placed at a node, however, no heating effect should be experienced. In the middle of a vibrating segment, the heating effect should be a maximum. Prof. Jones finds no absolute nodes or places of no electric current in a finite wire of considerable length, along which short Hertz waves are travelling and being reflected; but he finds places of minimum heat. The damping out of the waves prevents the interference of direct and reflected waves from being complete; there is a certain proportion of stationary waves, and a certain proportion of progressive waves, the latter disturbing the thermopile equally, whatever its position. One of the most interesting things observed was that if the receiving plates attached to the wires were placed very near to the vibrator, then scarcely any waves were excited; the energy of the vibrator seemed to be consumed by the receiver; the two probably oscillating together in opposite phases, and leaving very little disturbance to be propagated to a distance. Or it may be expressed by saying (as Mr. Blakesley suggested the other day at the Physical Society) that the virtual self-induction of the emitter was so much reduced by the mutual induction of the receiver that no sufficient inertia was left, and the oscillations were almost killed—the discharge being made dead-beat. It is a question whether the thermopile and galvanometer can be a very good plan of detecting nodes and ventral segments along wires; and it is surprising that it is sufficiently sensitive to show them. The fact that it is so, and that loops of thin iron, such as lead to the galvanometer, do not seem to disturb the position of the nodes is interesting.

Next a Paper was read from Mr. W. Thorp, relating some experiments he had made in Prof. Fitzgerald's laboratory, on the propagation of Hertz waves along very thick and very thin wires. Elementary theory indicates that the velocity of pulses along thin wires should be the same as in air, and along thick ones a trifle slower. But Mr. Thorp finds that the velocity (as indicated by wave length) is greater along brass gas-pipe of about an inch diameter than it is along copper wire less than the tenth of a millimetre thick. If this observation is confirmed, it will want serious consideration. Many observers measured the rate of travel along wires, and found it practically equal to the velocity of light, but they have not examined thicknesses so different as those Mr. Thorp uses. It remains to be found whether the resistance of excessively thin wires is able to retard the pulses, and cause them to travel much more slowly than they otherwise would. At present Mr. Thorp's observation is a most interesting possibility, which needs confirmation and development.

An important Paper from Lord Rayleigh concluded the work of this day. It was purely optical, and relates to the amount of light reflected at the polarising angle from clear liquids. Brewster's simple law of polarisation, that the tangent of the polarising angle was equal to the index of refraction, or that the reflected and transmitted rays were perfectable to each other when the reflected light is completely polarised, has been shown by Janin to be only an approximate statement. It does give the angle of *maximum* polarisation, but the polarisation is not complete except for substances whose index of refraction is about 1·5. For all other substances some amount of elliptic polarisation was produced by the reflexion, and no completely polarised light could be obtained. But now Lord Rayleigh, experimenting on almost absolutely clear liquid surfaces, finds that the ellipticity is much less—in fact, a thousand times less—than Janin supposed. And he evidently surmises that the faint residual trace of elliptic polarisation is due to a still remaining trace of surface impurity, or to an imperfectly sharp transition from one medium to the other. Thus, at any rate, to a high degree of accuracy, Brewster's law is restored in all its simplicity, and will probably be found to apply to all transrapent substances whose surfaces are absolutely clean. The

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ellipticity detected by Janin and other observers has its origin in that fine layer of dirt on the surface of bodies which only considerable skill and care can remove.

On Saturday the Section found it unfortunately necessary to divide, and to sit half of it for pure mathematics and the other half for electrolysis and physical chemistry. A very valuable table involving an immense amount of compilation work was handed in by the Rev. T. C. Fitzpatrick, of Christ College, Cambridge, as part of the report of the Committee on Electrolysis. It endeavours to summarise and tabulate all that is known concerning the conductivity of solutions of the various salts at different strengths. It will, no doubt, be printed in the annual volume, and be long useful as a work of reference.

Mr. J. Brown criticised the recent writings of Prof. Ostwald and the arguments adduced by him in support of the dissociation theory of electrolysis, pointing out that many of them were equally reconcileable with the simple Grotthus chain theory In particular, he criticised an experiment which excited a good deal of interest at Leeds last year, viz., where copper nodules make their appearance on the face of a partition of ferrocyanide of copper interposed in the path of the current, as if they were filtered out by a "semi-permeable membrane," and left behind. Mr. Brown has examined this substance, the ferrocyanide of copper, and found it slightly metallically conducting. Now directly a conducting partition is interposed in the path of a current in metallic salt solution, nothing is more natural than to get a metallic deposit from it. Hence, he concludes that the experiment of Ostwald has no bearing whatever in favour of one theory rather than another; that it is in fact of no particular interest. Mr. Preece said that the nodules of copper found on the porous cells of Daniell's batteries were due to specks of conducting matter in the clay, and that by more carefully selecting the cells no such deposits were obtained. Unless something fresh can be adduced by Prof. Ostwald, there seems, therefore, to be no further mystery or interest in this dropping out of ions from the path of a current; a phenomenon which might have had considerable theoretical import, and which, apart from this conductivity explanation, was very puzzling.

Mr. Chattock gave an account of an elaborate series of measurements which for two years or more he has been making on the discharge of electricity from points. Many very interesting facts are being brought to light by this research; he has elaborated a method of measuring the atomic charge in gases, and has shown that it is something comparable to the known charge on atoms in electrolytes. His investigations also go to confirm the theory of Prof. J. J. Thomson with reference to molecular chains—a string of short Grotthus chains—which, by breaking down, bring about the electric discharge observed. All this work of J. J. Thomson in vacuum tubes, and of Chattock on ordinary and rarefied air near points, is closely related to the phenomena of electrolytic conduction in liquids, and before long the three sets of facts will certainly throw considerable light upon each other.

Prof. Ramsay described an ingenious method of measuring surface-tension by observing the size and flotation of a bubble of vapour in a narrow tube of liquid, especially with reference to the behaviour of ether near its critical point. And there were two other minor communications from Mr. R. L. Mond and Mr. Swinburne.

On Monday, among the most striking Papers was one by Dr. Copeland on the nature of the bright streaks on the moon, which are now for the first time explained and illustrated by a very beautiful model. The peculiarity of the well-known streaks radiating from Tycho and a few other craters is that they are only visible at full moon—that is, to an eye looking along the line of illumination. Dr. Copeland's plaster of Paris model, with very minute glass beads appropriately disposed on its surface, imitates this behaviour exactly.

Dr. Johnstone Stoney gave some account of his examination into the behaviour of atomic motions, subject to mutual perturbation of a kind similar to those which planets and satellites experience. He endeavours thus to account for the peculiarities observed in spectra, especially for the very frequent occurrence of double lines. He believes, indeed, that most lines will be found double when examined with sufficiently high power; and Dr. Webster on this head recounted some recent observations of Michelson by a very powerful interference method, whereby he had obtained evidence of doubleness in lines which have never been seen as otherwise than single. Evidently some very important progress is being made in this direction, viz., in ascertaining both by theory and observation the kind of inter-atomic motion and vibration to which the particular kind of radiation emitted by molecules and analysed in the spectroscope is due.

Mr. Clayden exhibited a number of beautiful meteorological photographs, taken by observers in different parts of the world; photographs of clouds, of lightning, of hoar frost, and of many other meteorological and interesting evanescent effects. The photographs of lightning are especially valuable, and the ribbon appearance so often seen is found to be produced even when the camera is quite fixed. True multiple effects likewise, however, occur, and these have been imitated, to some extent, by Mr. Clayden, by photographing simple Leyden jar sparks in the circuit of which greater or lesser resistance is interposed. Prof. Ogden N. Rood used to observe the direction of lightning by watching a cardboard disc, with radial spokes drawn on it, twirled on a shawl-pin during a thunderstorm on a dark night. Some flashes are instantaneous, others are multiple or intermittent. Doubtless the noisiest and most dangerous are the sudden ones. It is to be hoped that many observers will combine to swell the collection of lightning photographs being made by the committee, of which Mr. Clayden is secretary, and Mr. G. J. Symons chairman; and, if taken with due regard to the instructions which the committee will issue, they cannot help adding largely to our information concerning atmospheric discharges.

On Tuesday, after a report from the committee on Electrical Standards with reference to the minute changes going on among the wire and mercury standard of resistance, Mr. Swinburne gave a summary of a long and detailed piece of work on the causes of variation of Clark cells, which it was very difficult to follow ordinarily, but which will doubtless be very useful to experimenters interested in the practical construction of standard of E.M.F.

A discussion on electrical units was then commenced. The writer spoke on the naming of a coefficient of induction and of a unit of magnetic induction, both of which he believes to be needed in practice. If the secohm is to do for the one, the secvolt will do for the other; and the unit of field intensity would be a secvolt per square centimetre. He believes that a unit of magnetic induction or total number of lines of force passing through an armature coil is more immediately applicable to practical use than is the idea of a certain length of wire moving across a field with a specified velocity, as advocated by Prof. Perry. An induction of one secvolt passing through a coil is such that if the coil be rotated so as to cut out all these lines in one second, the average E.M.F. set up in every turn of it is one volt. It may also be expressed as a secohm × ampere. The secohm, or quadrant, or whatever it is to be called, is an inconveniently large unit, but *perhaps* it is better to adhere to the systematic arrangement, and not introduce any fresh multipliers, not even one-thousandth. It is for practical men themselves to decide this question, and the particular names to be employed for these units is also a matter of taste. Mr. Preece was expected to continue his advocacy of enlarging the present volt and ampere each 10-fold, and the present watt 100-fold, a procedure for which there is much to be said. Likewise, for altering the name of the microfarad to a farad, so that submultiples of it may conveniently be named, the farad itself being absurdly too big—greater than the capacity of the solar system. He did not, however, bring forward anything very revolutionary. Prof. W. Stroud, of Leeds, strongly advocated the change from present volt to one ten times as big, and from present ampere to the simple C.-G.-S. unit, which is likewise ten times as big; and pointed out that this simple change would get rid of all the present no-system of having to use 10, 10^7, 10^8, 10^9, and the reciprocal of these quantities as factors to count for C.-G.-S. units; and would make all the practical units be derived straight from the C.-G.-S. unit by multiplying either by 10^9 or by unity. It

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is a great pity that this 10^9 system was not adopted at first, but the meeting was evidently averse to any sort of change being introduced now. The tables drawn up by Prof. Stroud, showing the advantage of the changes advocated by him, were very thoughtful and well considered. Dr. Johnstone Stoney, who had had so much to say at the birth of the C.-G.-S. system, and who stood out for a more immediately metric system, because he saw that the dyne and erg would be too grotesquely small for engineers, said that, however much he regretted the adoption of the centimetre, it was too late now to alter it, and he proposed adhering to present units with a them simple method of naming multiples or submultiples of by any power of ten or one-tenth, which he had previously advocated,and which is frequently already used for wave-lengths.

A number of speakers followed, each pursuing his own line of thought, and the closing hour decided on by the sectional committee arrived before anything like agreement could be come to on any one point, and long before the discussion was half over. The extra subject of mechanical units (moments of inertia, and the like) remained perforce untouched. Some remarks were made deprecating the idea that resistance was really a velocity or capacity, or self-induction a length; and the need for retaining one of the unknown quantities k or μ, as a factor until further knowledge tells us its dimension and numerical value, was, as usual, insisted on.

At the University College adjacent to the Section Prof. J. Viriamu Jones exhibited in action his beautiful form of Loveni's method of determining the ohm. By means of a rotating disc inside a coil he determines the absolute specific resistance of mercury direct, aiming at an accuracy of one part in 10,000. He speaks of issuing absolute standards of very low resistance, say, one-thousandth of an ohm, &c., provided with tapping terminals as well as main terminals, so that an electrometer applied to them may be used for measuring very powerful currents.

The last Wednesday of the meeting was fully occupied by Section A, although all the other sections had concluded their labours. Prof. S. P. Thompson showed a delightfully handy rough spherometer, made by the Geneva Company, of Chicago, which, applied to a spectacle lens, gave its power in "dioptrics" at once, by the motion of an index; on the assumption, however, that the index of refraction of the glass was of average and fixed value.

Mr. Trouton described some curious and purely magnetic observations he had made on large iron rings submitted to a magnetising helix conveying an alternating current, and having another helix connected with a telephone arranged as feeler, and moved about over the ring. He thus found, to his surprise, nodes, or places of telephonic silence, as if the magnetic pulses took time to travel, and formed a system of stationary waves with nodes and ventral segments at regular intervals round the ring. Dr. Larmor suggested that the ring might be thrown into mechanical or Jouleian vibrations by the alternating current, and that the telephone coils might be affected by these slight motions, so as to give equal opposite effects on opposite sides of certain regions or nodes. The nodes could hardly be real magnetic interferences, because a galvanometer failed to show them. A telephone was essential.

Mr. W. Barlow showed some remarkably beautiful models of coloured beads, strung so as to imitate the arrangement of the atoms in various crystalline minerals. The physical characteristics of particular crystals were shown to be brought out by the atomic grouping necessitated by simple principles of symmetry, regarding each atom as a mere centre of force. Thus zinc blend showed its structural appearance. Quartz exhibited a spirals tructure, which might be either right or left handed, and which was known to be competent to explain its rotation of the plan of polarisation of light. Iceland spar had a complex structure, which had a twin or image of itself in a mirror, into which it could be forced over by appropriate displacement. It appears probable that, by long study of these matters, Mr. Barlow has been able to penetrate pretty far into the secrets of crystalline form and arrangement.

The remaining five Papers had, for want of time, to be taken as read. Thus ended a meeting which, though, perhaps, nothing specially brilliant or sensational can be asserted of it, maintained its usually high scientific level, and was representative of the immense amount of first-class work which is at the present time being accomplished in physical science.

REPORT OF THE ELECTRICAL STANDARDS COMMITTEE.

To the Right Honourable Sir MICHAEL HICKS-BEACH, Bart., M.P., President of the Board of Trade.

In compliance with the instructions contained in your minute of December 16th last, that we should consider and report whether any, and, if so, what, action should be taken by the Board of Trade under Section 6 of the Weights and Measures Act, 1889, with a view to causing new denominations of standards for the measurement of electricity for use for trade to be made and duly verified, we have the honour to submit the following report:—

1. Before coming to a decision as to the points referred to us, we were anxious to obtain evidence as to the wishes and views of those practically interested in the question, as well as of Local Authorities who are concerned in the administration of the Weights and Measures Acts.

2. With this view we prepared draft resolutions embodying the proposals which, subject to further consideration, appeared to us desirable, and forwarded copies to the representatives of various interests for criticism. Copies were also forwarded to the Press. The following bodies were also invited to nominate witnesses to give evidence before us:—

The Association of Chambers of Commerce of the United Kingdom.
The Association of Municipal Corporations.
The London County Council.
The London Chamber of Commerce.

3. In response to this invitation the following gentlemen attended and gave evidence:—

On behalf of the Association of Chambers of Commerce, Mr. Thomas Parker and Mr. Hugh Erat Harrison.
On behalf of the London Council, Prof. Silvanus Thompson.
On behalf of the London Chamber of Commerce, Mr. R. E. Crompton.

The Association of Municipal Corporations did not consider it necessary to offer any oral evidence, but the following resolution passed by the Law Committee of that body, was adopted by the Council of the Association:—

"The Committee are of opinion that, assuming that the science of electricity has advanced so far that it is now possible properly to define the three units referred to in the Board of Trade letter" (*i.e.*, the ohm, ampere, and volt) "and to construct an instrument for the purpose of standard measurement, the time has arrived for the Board of Trade to take action thereon."

4. In addition to the witnesses above referred to the following gentlemen were invited to give evidence, and we are indebted to them for valuable information and assistance.

Dr. J. A. Fleming.
Dr. Alexander Muirhead.

5. We also had the advantage of the experience and advice of Mr. H. J. Chaney, Superintendent of Weights and Measures, who, at the request of our chairman, was present at our meetings.

6. After a careful consideration of the questions submitted to us, and the evidence given by the various witnesses, we have agreed to the following resolutions:—

RESOLUTIONS.

1. That it is desirable that new denominations of standards for the measurement of electricity should be made and approved by Her Majesty in Council as Board of Trade standards.

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2. That the magnitudes of these standards should be determined on the electro-magnetic system of measurement with reference to the centimetre as unit of length, the gramme as unit of mass, and the second as unit of time, and that by the terms centimetre and gramme are meant the standards of those denominations deposited with the Board of Trade.

3. That the standard of electrical resistance should be denominated the ohm, and should have the value 1,000,000,000 in terms of the centimetre and second.

4. That the resistance offered to an unvarying electric current by a column of mercury of a constant cross-sectional area of one square millimetre, and of a length of 106·3 centimetres at the temperature of melting ice may be adopted as one ohm.

5. That the value of the standard of resistance constructed by a committee of the British Association for the Advancement of Science in the years 1863 and 1864, and known as the British Association unit, may be taken as ·9866 of the ohm.

6. That a material standard, constructed in solid metal, and verified by comparison with the British Association unit, should be adopted as the standard ohm.

7. That for the purpose of replacing the standard, if lost, destroyed, or damaged, and for ordinary use, a limited number of copies should be constructed, which should be periodically compared with the standard ohm and with the British Association unit.

8. That resistances constructed in solid metal should be adopted as Board of Trade standards for multiples and submultiples of the ohm.

9. That the standard of electrical current should be denominated the ampere, and should have the value one-tenth (0·1) in terms of the centimetre, gramme, and second.

10. That an unvarying current which, when passed through a solution of nitrate of silver in water, in accordance with the specification* attached to this report, deposits silver at the rate of 0·001118 of a gramme per second, may be taken as a current of one ampere.

11. That an alternating current of one ampere shall mean a current such that the square root of the time average of the square of its strength at each instant in amperes is unity.

12. That instruments constructed on the principle of the balance, in which, by the proper disposition of the conductors, forces of attraction and repulsion are produced, which depend upon the amount of current passing, and are balanced by known weights, should be adopted as the Board of Trade standards for the measurement of current whether unvarying or alternating.

13. That the standard of electrical pressure should be denominated the volt, being the pressure which, if steadily applied to a conductor whose resistance is one ohm, will produce a current of one ampere.

14. That the electrical pressure at a temperature of 62°F. between the poles or electrodes of the voltaic cell known as Clark's cell, may be taken as not differing from a pressure of 1·433 volts, by more than an amount which will be determined by a sub-committee appointed to investigate the question, who will prepare a specification for the construction and use of the cell.

15. That an alternating pressure of one volt shall mean a pressure such that the square root of the time average of the square of its value at each instant in the volts is unity.

16. That instruments constructed on the principle of Sir W. Thomson's Quadrant Electrometer used idiostatically, and for high-pressure instruments on the principle of the balance, electrostatic forces being balanced against a known weight, should be adopted as Board of Trade standards for the measurement of pressure, whether unvarying or alternating.

7. We have adopted the system of electrical units originally defined by the British Association for the Advancement of Science; and we have found in its recent researches, as well as in the deliberations of the International Congress on Electrical Units, held in Paris, valuable guidance for determining the exact magnitudes of the several units of electrical measurement, as well as for the verification of the material standards.

8. We have stated the relation between the proposed standard ohm and the unit of resistance originally determined by the British Association, and have also stated its relation to the mercurial standard adopted by the International Conference.

9. We find that considerations of practical importance make it undesirable to adopt a mercurial standard; we have, therefore, preferred to adopt a material standard constructed in solid metal.

10. It appears to us to be necessary that in transactions between buyer and seller a legal character should henceforth be assigned to the units of electrical measurement now suggested, and, with this view, that the issue of an Order in Council should be recommended, under the Weights and Measures Act, in the form annexed to this report.

(Signed) COURTENAY BOYLE. RAYLEIGH.
WILLIAM THOMSON. G. CAREY FOSTER.
P. CARDEW. R. T. GLAZEBROOK.
E. GRAVES. J. HOPKINSON.
W. H. PREECE. W. E. AYRTON

(Signed) T. W. P. BLOMEFIELD, Secretary.
July 23, 1891.

The following schedule is contained in the Draft Order in Council appended to the report:—

SCHEDULE.

I.—*Standard of Electrical Resistance.*

A standard of electrical resistance, denominated the ohm, being the resistance offered by the coil of metal marked ———— to the passage of an unvarying electrical current when the coil is in all parts at a temperature.

II.—*Standard of Electrical Current.*

A standard of electrical current, denominated the ampere, being the current which is passing in and through the coils of wire forming part of the instrument marked ————, constructed as described in a specification marked ————, when the instrument, being adjusted and used in accordance with the instructions contained in the said specification, indicates a balance between the electro-magnetic force resulting from the current in the said coils, and the force exerted by gravity in Westminster upon the platinum weight marked ————, and forming part of the said instrument.

III.—*Standard of Electrical Pressure.*

A standard of electrical pressure, denominated the, volt being one-hundredth part of the pressure applied between the terminals forming part of the instrument marked ————, constructed as described in a specification marked ————, when, the instrument being adjusted and used in accordance with the instructions contained in the said specification, its indicating needle points to the centre line of three lines delineated upon the dial face of the instrument between ———— degrees and ———— degrees.

In the use of the above-named standards the limits of accuracy attainable are as follows:—

For the ohm.—Within one hundredth part of one per cent.

For the ampere.—Within one tenth of one per cent.

For the volt.—Within one quarter of one per cent.

The coils, instruments, specifications, &c., referred to in this schedule are deposited at ————.

Note.

(1.) The standard ohm has the value of 1,000,000,000 in terms of the centimetre and the second of time.

The Board of Trade have found that the value of the standard of resistance constructed by a Committee of the British Association for the Advancement of Science, in the years 1863 and 1864, and known as the British Association Unit, may be taken as 0·9866 of the standard ohm.

(2.) The standard ampere has the value one-tenth (0·1) in terms of the centimetre, the gramme, and the second of time.

The Board of Trade have found that an unvarying current which, when passed through a solution of nitrate of silver in water, in accordance with the specification marked ————, deposits silver at the rate of 0·001118 of a gramme per second, may be taken as a current of one ampere.

(3.) The standard volt is a pressure such that, if steadily applied to a conductor whose resistance is one ohm, it will produce a current of one ampere.

The Board of Trade have found that the electrical pressure at a temperature of 62°F. between the poles or electrodes of the voltaic cell, known as Clark's cell, may be taken as not differing by more than ———— parts in one thousand from a pressure of ———— volts.

* See *The Electrician*, July 24, 1891, p. 325.

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The Electrician.

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THUNDER.

Concentrating itself round the art of making efficient lightning conductors, some study has been made and some knowledge has been arrived at as to the behaviour of that awe-inspiring nuisance with which Jove was armed. The world is not so densely populated that anyone must needs dwell on the slope of an active volcano, unless impelled by the interests of science to live in a laboratory; and those who must perforce spend their days in a country tossed and riven by earthquakes may thankfully adopt any of the numerous unpatented devices for ensuring the stability of their houses, whether by the massive pendulum of the pagoda, by the "ball-bearing" foundation, or by the simplicity of a structure composed of bamboo and paper. But both Greek and barbarian, prince and pauper, are occasionally subjected to the visitation of thunderstorms, and have the highest scientific authority for doubting their immunity from sudden death, unless they seek refuge in a solidly constructed iron house, or, perhaps, the nearest Safe Deposit.

The phenomena of A and B discharges and the experimental study of laboratory lightning have presented considerable difficulties, both as regards explanation of the results, and more particularly as to the practical deductions which are to be made from them. Meanwhile, thunder, which to many persons is quite as terrible as lightning, has been completely disregarded, though it appears to us that some of its features are worthy of consideration, as throwing light on the nature and behaviour of lightning. While it is difficult to estimate the comparative loudness of thunder, we can very easily measure the distance of it, or perhaps of some part of

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it, by observing the time which elapses after the lightning flash. Sound travelling at 370 yards per second takes about 4¾ seconds to the mile, but as accuracy is not possible owing to the irregular occurrence of the lightning, and the uncertain commencement of the thunder, five seconds to the mile is quite near enough. Nineteen seconds corresponds with a distance of four miles, and beyond this thunder is not often heard, though lightning is frequently seen. Those philosophers who do not put their heads under the bed-clothes during a storm may make nocturnal observations by counting five and a-half pulse-beats to a mile. This estimate allows for the effect of the recumbent posture, but takes no account of nervous agitation for which a personal coefficient must be used. One of the first facts to be learned by thus reckoning the distance, is, that the noise of the thunder-claps, and presumably therefore the magnitude of the flashes, or, more strictly speaking, the energy expended in the flashes, vary perceptibly; but it is very rare that a flash one mile distant makes no more noise than an average flash three miles off, and presuming that the noise of distant thunder varies as the square of the distance, it appears that a discharge one-ninth of the magnitude of the average is uncommon. A very little attention will resolve thunder into three or four different parts, the crackle, the roar, the bang, and the rumble. The last is, without doubt, due to echo from neighbouring clouds, and is much more prominent in a mountainous country. The crackle is only heard in connection with a loud discharge, and more careful observation would probably show that it is only heard at comparatively short distances. The roar and the bang are generally associated, but each is frequently to be heard alone. Several bangs are often heard after a flash which appears to be single. The crackle invariably precedes the more noisy part of the clap, if it is heard at all.

It is generally, and with good reason, assumed that a flash of lightning raises to incandescence the air along its path, and that thunder is the result of the thermal expansion of the air, but it is not clear whether the vibrations are set up directly by the sudden expansions, or by the collapse of the surrounding atmosphere upon the partial vacuum. It would appear, at first sight, as though the crackle might be due to the disruption and sudden expansion of the air, and that the thunder is caused by the collapse, but if this were the case, a similar result should be produced by the free explosion of any detonating compound, and we are not aware that any such double sound has been heard. The crackle must, therefore, be due to something which precedes the flash, and may be caused by a few small local discharges during the building up and concentration of the stress at the ends of the impending flash. The succeeding roar and bang can be easily accounted for, and it seems clear that the roar is by no means the same as the rumbling echo. Taking, as a simple case, a nearly straight flash of lightning a mile in length, the observer being stationed at a distance, in the direction of the flash, the noise travelling to him from all parts of it will come upon him continuously for a period of nearly five seconds; and this is a plausible explanation of a roar. If, on the other hand, he receives a broadside, being stationed so that all parts of the flash are equidistant from him, he will hear a bang. If lightning followed the conventional zig-zag path with which artists have made us familiar, but which is conspicuously absent from actual photographs, a number of bangs connected by roars would be the natural result of the above reasoning. It is possible that some of the complications of a peal of thunder may be due to the successive arrivals of the sound from different parts of a single flash, but they are probably due in most cases to multiple or successive flashes. Many photographs of lightning show the branching of a single discharge into a number of separate paths, and even if all these exist simultaneously they will be at different distances from an observer, and the thunder will, of course, consist of a number of explosions corresponding to the number of branches. Explanations of successive flashes have been given by Dr. Oliver Lodge, and the quivering appearance which is often presented by a flash of lightning has been resolved by a moving camera into a number of separate discharges. When these flashes follow practically the same path, the whole series lasting, as often happens, less than half a second, the thunder would not differ much from that of a single flash. Very frequently the first bang is not the loudest, but a long peal works up to a maximum and then seems to expend itself gradually. Photographs of branched flashes afford an explanation of this. The whole thunder clap is produced practically at the same instant, but the noise due to those outlying branches which are nearest to the observer form the commencement of the peal, the others follow, and being succeeded by the farthest stragglers, suggest a series of explosions.

But however much windows may rattle and buildings tremble, we never hear of a pane of glass being broken by *thunder*, yet a cannon of no extraordinary size will break every window in the neighbourhood by the concussion of its discharge; the glass, for some reason not clearly explained, always falling outwards. The sound of cannon fire can, moreover, easily be heard at fifteen or twenty miles, and occasionally at two or three times this distance. Even on this slender basis it seems safe to argue that the volume of air which is heated by a flash of lightning is considerably less than that of the gases liberated by a charge of powder in a large cannon. The traditional tribute of awe which is paid to it notwithstanding, thunder, it would therefore seem, is but a small scale operation after all, and as much inferior from the point of view of mere "bigness" to the manufactured article, as lightning is for all useful purposes to a 30,000 volt "rotary current."

ELECTROMAGNETIC THEORY.—XV.

BY OLIVER HEAVISIDE.

(*Continued from page 441*).

§ 82a. But the magnetic stress has other work to do than to move elastically magnetised matter under the circumstances stated. Wholly independent of magnetisation, it produces the very important moving force on conductors supporting electric current, first mathematically investigated by Ampère.

The lateral pressure of the stress here comes prominently into view, when we ignore the stress in the interior of the conductors, so that the stress vector in the air at the boundary of a conductor represents the moving force on it per unit area. Thus, two parallel conducting wires supporting similar currents attract one another, because their magnetic forces are additive on the sides remote from one another, rendering the lateral pressure on them greater there than on the sides in proximity. But when the currents are dissimilar the magnetic force is greater on the sides in proximity, and, therefore, the lateral pressure of the stress is greater there, producing repulsion.

Proceeding further, and considering the stress within the conductor also, according to the same law, we find this peculiarity. In the case of unmagnetisable conductors (typified practically by copper), there is no superficial discontinuity in the stress, and therefore no surface forcive of the kind stated. This may be easily seen from § 79, translating the results from the electric to the magnetic stress. There is no tangential discontinuity in the stress because the normal induction and tangential magnetic force are continuous; and there is no discontinuity in the normal component of the stress because (since

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there is no difference of inductivity) the normal magnetic force and the tangential induction are also continuous.

In (5), (6), (7) turn E to H, and D to B, and U to T, and note that (5), as transformed, are true when the force and flux are exchanged, so that the transformed expressions (6) or (7) vanish.

In the case of a real conductor, therefore, with finite volume density of electric current, the moving force is distributed throughout its substance; and the variation of the stress indicates that the translational force per unit volume is expressed by

$$\mathbf{F} = V\mathfrak{C}\mathbf{B}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (16)$$

where $\mathfrak{C}$ is the current density. This is what Maxwell termed "the electromagnetic force," and it is what is so extensively made use of by engineers in their dynamos, motors, and things of that sort. It is probable, I think, that in grinding away at the ether they also stir it about a good deal, though not fast enough to produce sensible disturbances due to etherial displacement.

§ 83. There is next the force on intrinsically magnetised matter to be considered in connection with the magnetic stress. This is, perhaps, the most difficult part of magnetic science. Although, so far as the resultant effect on a magnet is concerned, we need not trouble about its internal state, but, as before, merely regard it as being pushed or pulled by the stress in the surrounding air, such stress being calculable from the distribution of magnetic force immediately outside it, as modified by the magnet itself, yet it is impossible that the real forcive can be represented merely by the surface traction $\mathbf{P}_N$.

Now, it is possible to find a distribution of magnetification over the surface, which shall be externally equivalent to the interior magnetisation, or to whatever other source of induction there may be. Then we may substitute for the surface traction $\mathbf{P}_N$, another traction, namely, upon the surface magnetification.

Or, we may find a distribution of fictitious electric current upon the boundary of the magnet, which shall be externally equivalent to the interior sources, and then represent the forcive by means of fictitious electromagnetic force on this current, § 82.

Or we may combine these methods in various ways. Evidently, however, such methods are purely artificial, and that to obtain the real forcive we must go inside the magnet. This can only be done hypothetically, and with precarious validity. One way of exhibiting the mechanical action on a magnet, or on magnetised matter generally, is that given by Maxwell in his chapter on the stresses (Vol. II.). This I believe to be quite erroneous for many reasons, the principal being that it does not harmonise with his scheme generally, and that it lumps together intrinsic and induced magnetisation, which have essential differences and are physically distinct. There are many other ways of exhibiting the resultant force and torque as made up of elementary forces, acting upon magnetisation, or on free magnetism, or on the variation of magnetism estimated in different ways. It is unnecessary to enter into detail regarding them. Nobody would read it. It will be sufficient to point out the particular way which harmonises with Maxwell's scheme in general, in the form in which I display it, with a special estimation of magnetic energy. Proportionality of force and flux is assumed. The want of this proportionality is quite a separate question. Given a definite relation between force and flux, the accompanying change in the stress vector, in accordance with the continuity of energy, can be estimated. This I have recently shown how to do in another place, which shall not be more explicitly referred to.

Intrinsic magnetisation possesses the peculiarity that it is, in a manner, outside the dynamical system formulated in the electromagnetic equations, inasmuch as it needs to be exhibited in them through the medium of an impressed force, although this is disguised in the ordinary mode of representation. Calling this intrinsic magnetic force $\mathbf{h}_0$ (any distribution), as before, the induction due to it in a medium of any inductivity (varying continuously or abruptly, if required) is found in the same way as the displacement due to intrinsic electric force in a non-conducting medium of similarly distributed permittivity; or as the conduction current due to the same in a medium of similar conductivity; or, to make a fourfold analogy, as the magnetic conduction due to $\mathbf{h}_0$ current in a (fictitious) medium of similar magnetic conductivity.

I may here point out that a clear recognition of the correct analogies between the electric and magnetic sides of electromagnetism is essential to permanently useful work. Many have been misled in this respect, especially in comparing Maxwell's displacement with magnetic polarisation. The true analogue of $\mathbf{D}$ is $\mathbf{B}$. Investigations based upon the false foundation mentioned can lead to nothing but confusion. There are enough sources of error without bringing in gratuitous ones.

Now, presuming we have induction set up by $\mathbf{h}_0$, how is the energy to be reckoned? I reckon its amount per unit volume to be $\frac{1}{2}\mathbf{HB}$ generally, whether outside or within the magnet; or, in the usual isotropic case, $\frac{1}{2}\mu H^2$ or $\frac{1}{2}\mu^{-1}B^2$. This makes the total work done by $\mathbf{h}_0$ to be $\mathbf{h}_0\mathbf{B}$ per unit volume, if $\mathbf{h}_0$ is suddenly established; of which one half is wasted, and the rest remains as stored magnetic energy. That is,

$$\Sigma T = \Sigma\tfrac{1}{2}\mathbf{h}_0\mathbf{B} = \Sigma\tfrac{1}{2}\mathbf{HB}, \quad . \quad . \quad . \quad . \quad (17)$$

if the Σ indicates space-summation. If $\mathbf{h}_0$ be suddenly destroyed, the energy ΣT is set free and is dissipated, mainly by the heat of currents induced within the magnet itself and surrounding conductors. This is the meaning of $\frac{1}{2}\mathbf{HB}$ being the stored energy per unit volume. But it may not be immediately available. To take an extreme case, if we have a complete magnetic circuit, so magnetised intrinsically that there is no external field, the energy, as above reckoned, is the greatest possible, since $\mathbf{H} = \mathbf{h}_0$. But it is now not at all available, unless $\mathbf{h}_0$ be destroyed. On the other hand, Maxwell would appear to have considered the energy of a magnet to be $\Sigma\frac{1}{2}\mu(\mathbf{H}-\mathbf{h}_0)^2$, which is zero in the just mentioned case. This reckoning does not harmonise with the continuity of energy, although it has significance, considered as energy more or less immediately available without destruction of $\mathbf{h}_0$. The connection of the two reckonings is shown by

$$\Sigma\tfrac{1}{2}\mathbf{h}_0\mathbf{B} = \Sigma\tfrac{1}{2}\mathbf{h}_0\mu\mathbf{h}_0 - \Sigma\tfrac{1}{2}(\mathbf{H}-\mathbf{h}_0)\mu(\mathbf{H}-\mathbf{h}_0); \quad . \quad (18);$$

or, when $\mathbf{H}$ and $\mathbf{B}$ are parallel,

$$\Sigma\tfrac{1}{2}\mathbf{h}_0\mathbf{B} = \Sigma\tfrac{1}{2}\mu\mathbf{h}_0^2 - \Sigma\tfrac{1}{2}\mu(\mathbf{H}-\mathbf{h}_0)^2 \quad . \quad . \quad . \quad (19).$$

Now, according to the reckoning (17) of the stored energy, and the consequent flux of energy, the stress vector derived therefrom indicates that the moving force per unit volume is

$$\mathbf{F} = V\mathbf{j}_0\mathbf{B}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (20),$$

where

$$\mathbf{j}_0 = \text{curl}\,\mathbf{h}_0. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (21).$$

The interpretation is that the vector $\mathbf{j}_0$ represents the distribution of (fictitious) electric current, which would, under the same circumstances as regards inductivity, set up, or be associated with, the same distribution of induction $\mathbf{B}$ as the intrinsic magnet is. It may be remarked that the induction due to an intrinsic magnetic force does not depend upon *its* distribution primarily, but solely upon that of its curl.

Substituting this current system for the intrinsic magnetisation, equation (20) indicates that the moving force is "the electromagnetic force" corresponding thereto, according to (16), § 82. The accompanying surface distribution of current, representing the abrupt cessation of $\mathbf{h}_0$, must not be forgotten; or we may let it cease gradually, and have a current layer in the skin of the magnet. It may be far more important than the internal current, which may, indeed, be non-existent. For instance, in the case of a uniformly longitudinally magnetised bar, the equivalent current forms a cylindrical sheet round the magnet. In general, the surface representative of $\mathbf{j}_0$ is

$$V\mathbf{N}\mathbf{h}_0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (22)$$

where $\mathbf{N}$ is a unit normal drawn from the boundary into the magnet. It should also not be forgotten that if the inductivity changes, there is also the moving force (15) or (14) to be reckoned, besides that dependent upon the intrinsic magnetisation.

§ 84. The electric analogue of intrinsic magnetisation is intrinsic electrisation, represented in a solid dielectric in which

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"absorption" has occurred, and perhaps in pyroelectric crystals. It seems very probable that there is a true electrisation, quite apart from complications due to conduction, surface actions, and electrolysis. When formulated in a similar manner to intrinsic magnetisation, by means of intrinsic electric force $\mathbf{e}_0$ producing displacement according to the permittivity of the medium (which displacement, however, is now also affected by the presence of conducting matter), and with a similar reckoning of the stored energy, viz., $\frac{1}{2}c\mathrm{E}^2$ per unit volume, where $\mathbf{E}$ includes $\mathbf{e}_0$, we may expect to find, and do find, a moving force analogous to (20), viz.,

$$\mathbf{F} = \mathrm{V}\mathbf{D}\mathbf{g}_0, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (23)$$

where

$$\mathbf{g}_0 = -\operatorname{curl} \mathbf{e}_0 \quad . \quad . \quad . \quad . \quad . \quad . \quad (24).$$

That is, magnetoelectric force on the fictitious magnetic current $\mathbf{g}_0$ which is equivalent to the intrinsic force $\mathbf{e}_0$. And, similarly to before, we may remark that the flux due to $\mathbf{e}_0$ depends solely upon its curl.

§ 85. Now bring together the different moving forces we have gone over. On the electric side we have

$$\mathbf{F}_e = \mathbf{E}\rho - \tfrac{1}{2}\mathrm{E}^2\nabla c\,[+\mathrm{V}\mathbf{D}\mathbf{K}] + \mathrm{V}\mathbf{D}\mathbf{g}_0, \quad . \quad . \quad (25),$$

and on the magnetic side

$$\mathbf{F}_m = [\mathbf{H}\sigma] - \tfrac{1}{2}\mathrm{H}^2\nabla\mu + \mathrm{V}\mathbf{C}\mathbf{B} + \mathrm{V}\mathbf{j}_0\mathbf{B}, \quad . \quad . \quad (26),$$

where the third term on the right of (25), and the first on the right of (26), in square brackets, are zero; $\mathbf{H}\sigma$ being force on magnetification and $\mathrm{V}\mathbf{D}\mathbf{K}$ the magnetic analogue of $\mathrm{V}\mathbf{C}\mathbf{B}$. The other component forces can all separately exist, and in stationary states.

Passing to unrestricted variable states, with motion of the flux-supporting media also, the electric and magnetic stress vectors indicate that the moving forces arising therefrom are obtainable from those exhibited in (25), (26), by simply changing the meaning of the electric current and the magnetic current symbols in the third terms on the right. Above, they stand for conduction current only, and one of them is fictitious. They must be altered to $\mathbf{G}_0$ and $\mathbf{J}_0$, the "true" currents, as explained in § 66. Thus

$$\mathbf{F}_e = \mathbf{E}\rho - \tfrac{1}{2}\mathrm{E}^2\nabla c + \mathrm{V}\mathbf{D}(\mathbf{G}_0 + \mathbf{g}_0), \quad . \quad . \quad (27)$$

$$\mathbf{F}_m = [\mathbf{H}\sigma] - \tfrac{1}{2}\mathrm{H}^2\nabla\mu + \mathrm{V}(\mathbf{J}_0 + \mathbf{j}_0)\mathbf{B}, \quad . \quad . \quad (28)$$

express the complete translational forces due to the electric and magnetic stresses (31), (32), § 72.

The division of the resultant translational force into a number of distinct forces is sometimes useless and artificial. But as many of them can be isolated, and studied separately, it is not desirable to overlook the division.

The equilibrium of a dielectric medium free from electrification and intrinsic forces, which obtains when the electric and magnetic forces are steady, is upset when they vary. There is then the electromagnetic force in virtue of the displacement (electric) current and the magnetoelectric force in virtue of the magnetic current; that is,

$$\mathbf{F} = \mathrm{V}\dot{\mathbf{D}}\mathbf{B} + \mathrm{V}\mathbf{D}\dot{\mathbf{B}} \quad . \quad . \quad . \quad . \quad . \quad (29)$$

$$= \frac{d}{dt}\mathrm{V}\mathbf{D}\mathbf{B} = \frac{1}{v^2}\frac{d\mathbf{W}}{dt}, \quad . \quad . \quad . \quad . \quad (30),$$

where $\mathbf{W}$ is the flux of energy. Here we neglect possible small terms depending on the motion of the medium.

That there should be, in a material dielectric, moving force brought into play under the action of varying displacement and induction does not present any improbability. But it is less easy to grasp the idea when it is the ether itself that is the dielectric concerned. Perhaps this is, for some people, because of old associations—the elastic solid theory of light, for instance, wherein displacement of the ether represents the disturbance.

But if we take an all round view of the electromagnetic connections and their consequences, the idea of moving force on the ether when its electromagnetic state is changing will be found to be quite natural, if not imperatively necessary. We do know something about how disturbances are propagated through the ether, and we can, on the same principles, allow for bodily motion of the ether itself. Further, reactions on the ether, tending to move it, are indicated. But here we are stopped. We have no knowledge of the density of the ether, nor of its mechanical properties in bulk, so, from default of real data, are unable to say, except upon speculative data, what motions actually result, and whether they make any sensible difference in phenomena calculated on the supposition that the ether is fixed.

(To be continued.)

MAGNETISM IN IRON AND OTHER METALS.*—XLVIII.

BY PROF. J. A. EWING, F.R.S.

(Continued from page 407.)

§ 166. **Molecular Theories: Poisson and Weber.**—We know that when a piece of iron, or other magnetic metal, is magnetised, the magnetic state permeates the whole piece. A steel bar magnet may be broken up into small pieces, and every piece is found to exhibit magnetic polarity. Assuming the structure to be molecular, it is inferred that each molecule of the magnetised bar is a magnet. Taking a row of molecules in the direction of the magnetisation, we have the north pole of one contiguous to the south pole of the next, and so on along the row—with the result that it is only at the ends of the row that free poles appear. Imagine the row to be broken into two or more parts, however, and each segment of it has free poles at its ends.

The individual molecules of a magnetised bar, then, are magnets, and the question next arises whether they become magnets only when the bar is magnetised. Does the process of magnetising consist, as Poisson suggested, in making each molecule become a magnet? Or are we to adopt Weber's view, according to which the molecules are always magnets, showing no aggregate polarity in an unmagnetised piece, only because their axes point in all directions at random, but turning into line when a magnetising force is applied? According to Poisson, there is no need to suppose the molecules capable of moving within the bar, but we must suppose that magnetic polarity can be induced in the individual molecules. In other words, the question how induction happens is only shifted from the bar to the molecule, and is brought no nearer to a solution. According to Weber, on the other hand, the molecules are to be conceived as free, more or less, to turn and take up a new alignment, very much as a pivotted compass needle will turn when it is directed by a magnetic field; but there is no need to imagine any development of polarity within the molecule itself. The Weber molecule is a magnet before the force begins to act, and the amount of magnetism in it need suffer no change however widely the magnetism of the bar be altered. Hence Weber's theory explains the process of induction to this extent, that it makes the magnetic change of the bar be brought about by a change in the position of the molecules, and not by any change in the quality of the molecules. Of the two views Weber's is the one that consorts best with our general understanding of the characteristics of molecules. Moreover, it receives strong support from certain of the known facts of magnetic induction.

§ 167. **Experimental Evidence in favour of Weber's Theory from the facts of Saturation, &c.**—It would be difficult, in Poisson's theory, to give any reason for the manner in which the magnetisation of iron tends toward a limit as the magnetising force is increased. If the process consists in the development of magnetic polarity in the individual molecules there is no obvious reason why it should not admit of being extended without limit, nor why the relation between the magnetism of a bar and the magnetising force should have the exceedingly complex character it is known to possess. We should rather expect to find proportionality, or something like proportionality, between magnetism and magnetising force, and we should not expect to find residual magnetism or other phenomena of hysteresis. Weber's theory, on the other hand, implies that there must be a limit to the intensity of magnetisation. The limit is reached when all the molecules have become turned to face exactly in the direction

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of the applied magnetising force; no increase of the force beyond what is required for that can add to the magnetisation. The fact that a definite saturation value is now known to exist* adds much probability to Weber's hypothesis. Further, the process by which the molecules are supposed to turn hither and thither under varying magnetising forces, leaves ample room, as we shall presently see, for a satisfactory explanation of all the features which the curves of magnetisation are known to present, and the various manifestations of hysteresis become intelligible. Again, the effects of vibration in augmenting magnetic susceptibility are readily accounted for in consequence of the greater freedom which vibration gives the molecules to fall into line with the magnetising force. Additional evidence is furnished by experiments such as that of Beetz, in which the effects were observed of applying a weak magnetising force to iron at a time when the molecules were peculiarly free to respond to its directive action, namely, while they were in the act of being deposited by the electrolysis of an iron salt. The iron was deposited along a line made by scribing a longitudinal scratch on a straight piece of varnished silver wire. The wire was immersed in the iron salt, and was placed in a magnetic field in such a manner that the lines of force ran in the direction of the length. The silver wire formed one pole of an electrolytic cell, and it was found that the metal deposited on the scratch was so highly magnetised that the subsequent application of a much stronger magnetic field failed to augment its magnetism more than a very little. The molecules had been ranged at the moment when they escaped from imprisonment in the salt, and before they had the opportunity of forming fresh entanglements by their action on one another; just as criminals are said to be most easily diverted into regular courses at the moment of their release from gaol, before they have time to resume the ties of their usual companionship. Not only is Weber's notion of molecular magnets strongly supported by this experiment of Beetz, but the cumulative evidence in its favour which is supplied by many facts of more recent observation may be said to give it almost conclusive proof. We may even build up a model consisting of small permanent magnets, such as Weber's theory postulates, in which all the chief characteristics of magnetic induction can be closely imitated. The study of a model of this kind leaves little room for doubt that the basis of Weber's theory, namely, the hypothesis of permanently magnetic molecules, is essentially sound.

§ 168. **Constraint of the Molecular Magnets in Weber's Theory.**—It is clear that if the process of magnetic induction is to be explained as the turning of molecular magnets so that they tend to face one way, the molecules must be subject to some directive force which prevents them from responding with perfect freedom to the magnetising field. Without some such constraint they would at once take the direction of the applied field, and the weakest magnetising force would suffice to produce saturation. In fact, however, magnetisation goes on progressively as the magnetising force is increased, and at every stage the direction taken by each molecule is determined by a balance between the force of the field which tends to turn the molecule, and some other directive force which opposes the turning.

Weber supposed that in a piece of virgin iron the axes of the molecular magnets point indifferently in all directions, and that when a magnetising force **H** is applied, each molecule is deflected against a directive force, which tends to restore it to its original position. He assumes this force to be that which would be exerted by a magnetic force of some constant value, **K**, acting in the primitive direction of the molecule's axis. The direction in which the molecule points while the magnetising force acts is consequently the direction of the resultant of **H** and **K**, and when the external force **H** is removed, the molecule is brought back by **K** to its primitive position. This theory of the constraint of the molecules gives no explanation of residual magnetism or other manifestations of hysteresiss. According to it, the magnetic susceptibility should be constant for all values of **H** less than **K**, and should diminish for higher values of **H**†. At the stage when **H** becomes equal to **K**, and the proportionality of magnetisation to magnetising force ceases, the value of **I** should be $\frac{2}{3}$ of the final or saturation value. This hypothesis is inconsistent of the fact that the early part of the curve of magnetisation is not straight; that the susceptibility is small at first, and increases with increasing magnetising force. This, indeed, is an example of hysteresis, and for the phenomena of hysteresis the theory, in this form, affords no room.

§ 169. **Maxwell's Modification of Weber's Hypothesis.**—To remedy this defect Maxwell has suggested a further assumption, based on the analogy of magnetisation to mechanical strain, with the object of admitting conditions under which the position of equilibrium of the molecular magnets may be permanently altered. He supposes that when a molecule is deflected by a magnetising force **H** it returns completely to its primitive position on the removal of **H** provided the deflection has been less than a certain value, but returns only partially if the deflection has exceeded that value. In the latter case its axis, when **H** is removed, remains turned through an angle which may be called the permanent set of the molecule. Maxwell has examined the consequence of this supposition at some length, assuming the molecules in a given piece to be all capable of the same or nearly the same amount of elastic deflection, and assuming a constant or nearly constant directive force, **K**, to act on each in the primitive direction of its axis. This hypothesis accounts for the existence of residual magnetism, and for some of the phenomena of hysteresis; it fails, however, to explain why hysteresis should be found when, after the first application, a magnetising force is removed and reapplied, and its postulates about directive force and the condition of permanent set are arbitrary. We shall see presently that by considering the action of the molecular magnets upon one another conclusions are reached which really embody Maxwell's idea of elastic and non-elastic deflection, though the directive force and the amount of elastic deflection is no longer arbitrary and no longer the same or nearly the same for all the molecules.

§ 170. **Hypothesis of Frictional Resistance to the Deflection of the Molecules.**—The suggestion has been made by Wiedemann and others that the deflection of Weber's molecular magnets is opposed by a species of frictional resistance, which not only resists the magnetisation, but accounts for residual magnetism and the effects of hysteresis by tending to hold the molecules from returning after they have been disturbed. A directive force, such as that postulated by Weber, is, of course, still necessary. Several of the observed phenomena might be adduced as supporting this notion; in particular, it harmonises well with the effects which are known to be produced by vibration and other mechanical disturbance in augmenting magnetic susceptibility, and in reducing residual magnetism; and also with the comparative suddenness with which the resistance to magnetisation breaks down when a certain stage in the magnetising process is reached. But if the molecules were held fast by friction until the applied force became sufficiently strong to start them, the susceptibility with respect to very feeble forces, should be zero, whereas, in fact, it has a small positive and initially constant value (§§ 86, 87). To make the notion of frictional control agree with the facts, it would be necessary to assume some further complication, such as that a few of the molecules in any given piece are sensibly free from friction, and may begin to turn under the influence of the weakest forces.

(To be continued.)

* The evidence of this has been fully stated above (§§ 91 to 107).

† See Maxwell's *El. and Mag.*, Vol. II., § 443.

The Electrical Trade Section and the Frankfort Exhibition.—The following letter has just been received by Mr. Kenric Murray from the Electro Technical Congress at Frankfort:—

DEAR SIR: We beg to acknowledge the receipt of your favour of the 21st of August. We are very glad to hear that about twenty members of the Electrical Trade Section of the London Chamber of Commerce will arrive here on the 6th of September for the Congress. In order to reserve the tickets for your members, we beg you to give us a list with the names of these gentlemen. Yet we add, that all your other members arriving here, and not mentioned on the list, may immediately get tickets on their demand. The tickets are not sent away, but are to be got *here* on personal presentation at our office of reception in the Electrical Exhibition, opposite the railway station.

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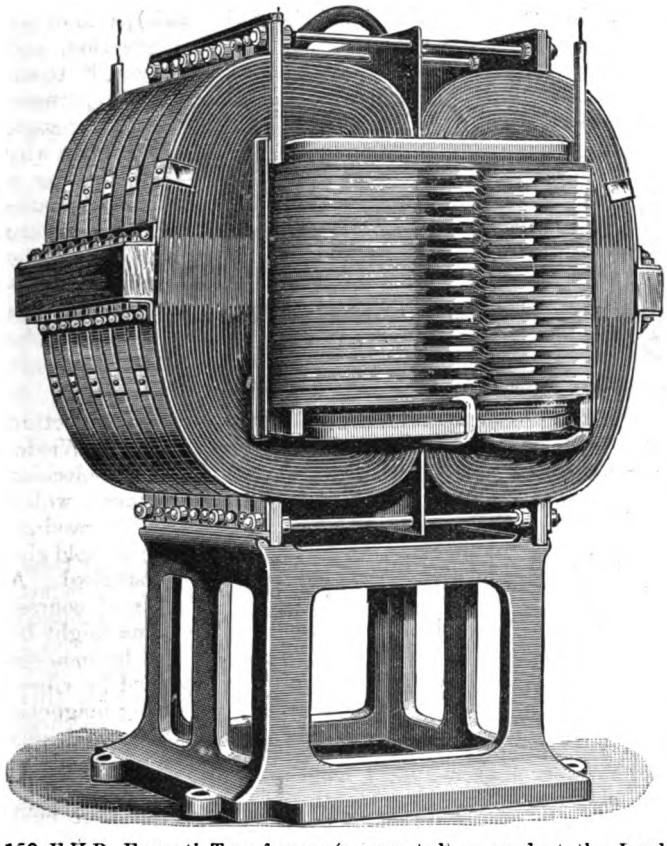
THE FERRANTI SUB-STATION TRANSFORMER.

The accompanying figure shows one of the Ferranti 150 H.P. transformers, specially designed as a sub-station instrument for reducing pressure from 10,000 or 5,000 to 2,400 or 2,000 volts. The transformer consists of three coils—viz., of one high-pressure coil, which is sandwiched in between two low-pressure coils. Each of these coils is composed of copper strip separated by a strip of vulcanised fibre and wound over with shellaced cloth and vulcanised fibre. In forming these coils a number of separate flat coils are built up one over the other, and connected together in series, insulating material being placed between every elementary coil. The high-pressure and low-pressure coils are separated from one another by sheets of ebonite, with a considerable air space between. The iron cores are exceedingly massive and formed of flat bands bent over in opposite directions to form closed magnetic circuits; the various layers of iron bands are separated from one another by an air space of ½in., to provide for ventilation, or, in cases where the transformer is placed in oil, to allow a free circulation to the oil.



150 E.H.P. Ferranti Transformer (unmounted) as used at the London Transformer Sub-stations.

It is advantageous to immerse these high tension transformers under the surface of an insulating fluid, diminishing thereby the liability to electrical discharge between the high-pressure coil and the iron frame, or the low-pressure coil which exists in virtue of the powerful electrostatic field in the neighbourhood of the high potential end of the high-pressure coil.

THE FERRANTI MAINS.

The five-and-twenty miles of concentric trunk mains on the Ferranti system connecting Deptford to the transformer sub-stations in the Metropolis have now been in successful operation for over six months under the "extra-high" pressure of 10,000 volts. This main is made in lengths of 20ft., and is jointed together by electrical or mechanical joints of a very ingenious character, of which, therefore, there are in the above-mentioned distance no less than 6,500. In the manufacture of this main, brazed copper tubes are taken, having equal cross sectional area, either ⅛in., ¼in., or ½in. section, calculated respectively to carry 125, 250, or 500 amperes. In the ¼in. section main, the copper tubes have the following dimensions. The inner conductor, or inner member, is a copper tube (see Fig. 1) of which the inside diameter of cross section will be called D_1, and radius R_1, and the outside diameter D_2, and radius R_2. The outer conduct, or member, is a copper tube of which the inside diameter will be called D_3, and radius R_3, and its outside diameter D_4, and radius R_4. The insulation between the inner and outer members is compressed brown paper and black wax. The values of the diameters and radii of cross section of these tubes are as follows:—

$D_1 = \frac{9}{16}$ of an inch = ·5625 in.
$D_2 = \frac{13}{16}$,, ,, = ·8125 ,,
$D_3 = 1\frac{27}{32}$,, ,, = 1·8437 ,,
$D_4 = 1\frac{15}{16}$,, ,, = 1·9375 ,,

Hence we have—

R_1 = ·281 in. R_1^2 = ·0789
R_2 = ·406 ,, R_2^2 = ·1648
R_3 = ·922 ,, R_3^2 = ·8500
R_4 = ·969 ,, R_4^2 = ·9389

$R_2^2 - R_1^2$ = ·0859,, $R_4^2 - R_3^2$ = ·0889

Hence the area of cross section of the inner member is $\pi (R_2^2 - R_1^2)$ = ·2689 sq. in., and that of the outer member is equal to $\pi (R_4^2 - R_3^2)$ = ·2793 sq. in., or approximately a quarter of a square inch. The copper resistance of the quarter-inch section main is ·324 legal ohms per mile run (including lead and return) when laid. The electrostatic capacity between inner and outer members is ·367 microfarads per mile run, and the capacity between the outer member and the iron casing about ten times as much. The inductance is 286 microhenrys per mile, and the dielectric resistance between inner and outer copper about 700 megohms per mile.

The first process in the manufacture of these mains is to roughly straighten the tube, though in many cases they require no attention. A roll of brown paper, 3ft. wide and several hundred feet in length, is placed at the end of a bench about 20ft. long, and is cut into pieces of this length. Close by are narrow benches, formed of a single plank, having a longitudinal groove near one edge. The copper tube is laid in this groove by a boy, who glues one edge of a strip of brown paper to it. The insulating paper which separates the outer from the inner conductor receives a coating of black mineral wax. A large roll of the paper is placed on trunnions at one end of a hot plate of about 35ft. in length. Beneath this several open fires are kept burning. The paper travels over this at about 20ft. per minute. It is thus thoroughly dried. It then passes over a roller into a tank containing melted ozokerit; it passes under a roller in this tank, and over another roller at the top. It then travels for some distance without touching any support, and during this period the wax sets firm. The paper is finally wound upon a drum. When a drum is full it is taken off and stored. The next process is to cut it up into sheets. A number of these are placed in a convenient position under the rolling machine, at which two or three men are employed in covering the inner conductor. This machine consists of a table, a wax tank, a roller, and turning gear. One of the cores, with its strip of brown paper attached, is brought from the stock, and a square ended plug is driven into each end. It is placed in the machine, and the square ends of the plugs are slipped into sockets which form part of the winding gear, and are fixed by set screws. At the back of the machine is a long tank containing melted ozokerit kept hot by gas burners. Several iron boxes hung from a roller are suspended in the liquid wax. The core being attached to the winding gear, and the brown paper being spread over the table in front of the machine, the iron boxes are lowered by turning the roller by means of a hand wheel and worm gear. The boxes displace the wax, and it flows up over the core. The winding gear is given a turn or two, and a sheet of waxed paper is drawn by two men from the stock of sheets kept below the table. The sheet is laid on the table, and the forward edge is fed in. On starting the winding gear the waxed sheet is caught between the

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dry paper and the core is wound in, being drawn under the melted wax. As soon as the winding is started, an iron roller is let down and rests on the revolving tube, compressing it well together. Additional sheets of waxed paper are fed on to the plate, overlapping the sheet which is being wound on, and passing under the melted wax. When the proper diameter has been reached, the roll is finished off by a spirally-wound tape. On being removed from the winding machine the square plugs are knocked out and the core is thrust into an outer copper tube, making a loose fit, for it would be impossible to push it in without injuring the paper if it fitted tight. The outer tube projects some six or eight inches beyond the inner, and this portion is flattened down and placed in the jaws of a draw-bench vice.

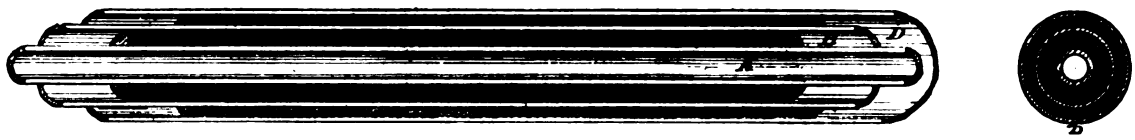

FIG. 1.—Ferranti Main.

A, Inner copper conducting tube. B, Outer copper conducting tube D, Iron protecting tube. (Insulation shaded black.)

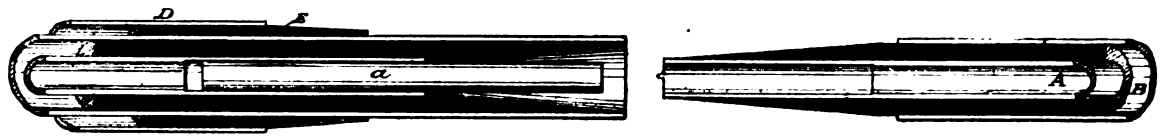

FIG. 2.—Ferranti Main prepared for Jointing.

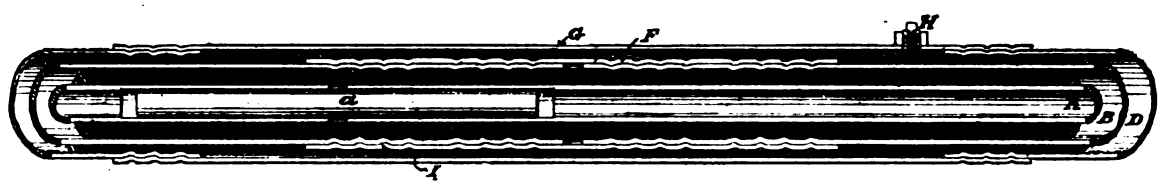

FIG. 3.—Ferranti Main Jointed.

A, B, D, as in Fig. 1. *a*, Copper rod. G, Iron sleeve. F, Copper sleeve. H, Screwhole. I, Interspace filled with melted wax.

The whole is then drawn through a taper die, and the outer tube is forcibly compressed on to the paper, and is, at the same time, slightly elongated. The ends are trimmed off by a circular saw, and as a concentric conductor the length is practically finished. For reasons which have been fully described in a Paper by Mr. Preece, it has been necessary to provide an outer insulation. The outer copper tube is insulated with a thickness of ¼in. of waxed paper, and is slipped into a tube of thin sheet iron, made with a brazed joint. The whole is then placed over an open fire, and melted wax is pumped into a tube drilled in the middle, and is forced outwards to the ends, thus completely filling the interspace with wax.

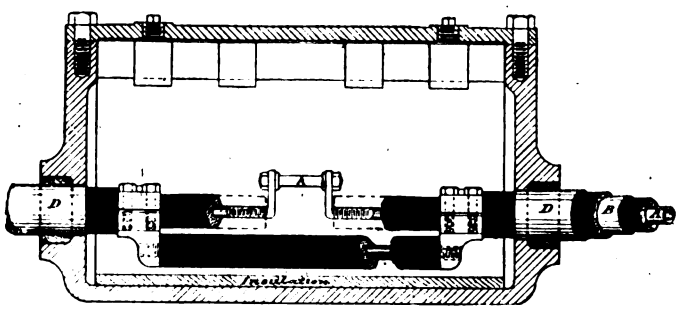

FIG. 4.—Ferranti Street Box. Sectional elevation.

The tubes so prepared, in lengths of 20ft., are then put into a lathe of peculiar construction, and the ends turned down in such a manner that one end is tapered off into a cone, as shown in Fig. 2 on the right, the insulating material being tapered down from the end of the outside copper to the end of the inside copper which projects some way beyond the outer tube. The other end of the main is turned down into a recessed or hollow cone, as shown in Fig. 2 on the left, the two cones being cut to precisely the same angle, so that the outside cone at the end of one main will fit into the recessed cone at the end of another one. The connection between the two inside tubes is made by forcing in a copper rod *a*, which is prevented from going in more than a certain length by a little shoulder on the inner copper tube.

In laying these mains, the process of making the joint is as follows:—The 20-feet lengths of main are laid down underground in wooden boxes, afterwards to be filled in with pitch, and the mains are separated by means of wooden bearers. The lengths of main having been laid down in the proper direction, a copper and an iron sleeve are slipped on over one end of the main. The copper rod is then pushed into the open end of the inner tube, and the two inter-fitting cones of two lengths of the main are forced together by an hydraulic press; the copper rod is rammed half into one inner tube, and half into the other, and forms a good electrical connection between the two inner copper tubes. The copper sleeve is then drawn over so as to connect together the two outer copper conductors, and is corrugated on to them by means of a peculiar tool, which compresses together the outer copper member of each 20-foot length and the copper tubular sleeve which connects them together. This tubular sleeve is

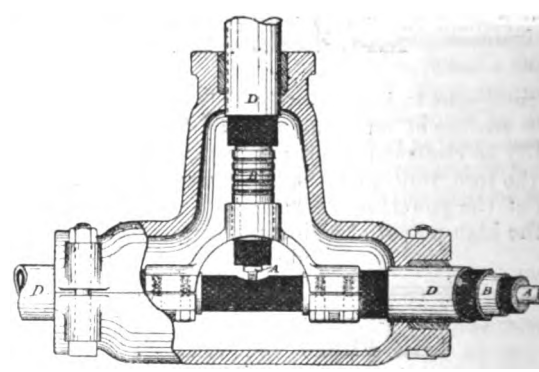

FIG. 5.—Ferranti Main. T Joint.

represented by F in Fig. 3. In the same way the iron sleeve G is then drawn over and corrugated on, connecting together the iron tubes of two adjacent 20-foot lengths, and the interspace I between the iron outer tubular sleeve and the inner copper sleeve is filled in with melted wax, forced in through a screw hole H, which is afterwards closed. In this way a joint is made in which the insulation between the outer and inner copper

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tubes is perfectly continuous, because the waxed paper cones weld together under the pressure in such a manner that they require very considerable force to pull them apart. In order to allow for expansion, bends are placed at intervals with a slight double curvature of an S shape. The wood troughing in which the mains are laid is then filled up with pitch and a wooden cover is laid over it.

At intervals in the main street, test boxes are inserted so that certain lengths of the main can be isolated for the testing. This street box is shown in elevation in Fig. 4. The ends of the cables are brought into the box at opposite ends, through stuffing boxes, and the inner copper members are approached to within a short distance. The inner copper members are then connected together by means of a crank-shaped copper connection, so made that by slacking the nuts the crank pin can be withdrawn, and the mains disconnected. The connection between the outer conductors is made by a copper clamp, which is wrapped over with waxed paper to insulate it from the box. The cover of the box is then bolted on, the box edges and cover being tooled to true surfaces. The box is finally pumped full of heavy resin oil. A junction is thus effected, capable of easy disconnection, and yet of withstanding 10,000 volts or more, and which is capable of being uncoupled very quickly for the purposes of isolating and testing certain lengths of main.

In cases where the junction has to be effected at right angles a T-joint box is employed of a very similar description. The box parts along the middle line, and the ends of the mains to be connected, are brought in through three stuffing boxes; a junction is effected between the inner members by a screw bolt which screws through the inner copper member of the main, and into the end of the inner copper member of the offset. Waxed paper insulation is then wrapped round this part, and the connection between the three outer copper members is made by a copper fork, clamped on as is shown in Fig. 5. When the joint is made the box is pumped full of resin oil.

THE FRANKFORT EXHIBITION.—IX.

(FROM OUR SPECIAL CORRESPONDENT.)

The following is a short record of the experiments made with the Lauffen-Frankfort plant:—Monday, August 24.—Short circuits caused several times in succession in the secondary wires to test the reliability of the safety fuses in the primary wires. These invariably acted instantaneously. Tuesday, August 25.—Some electric lighting done with the current from Lauffen, 600 16 c.p. 62 volt glow lamps being switched on, and a rotary current motor run without load. Wednesday, August 26.—A rotary current motor run with load. Overheating, however, caused a defect in the insulation, which resulted in a short circuit. The motor is now removed for repairs. Thursday, August 27—Sunday, August 30.—Lighting of 1,000—1,500 16 c.p. 62 volt glow lamps every morning and evening for three or four hours each time. The turbine at Lauffen, up till Sunday, has only run at half load, and the pressure used has, as yet, only reached 20,000 volts at times, the more usual pressure being only 13,000 volts. It is, however, intended to go as high as 25,000, or even 30,000 volts.

In a side room of the Siemens and Halske Exhibition in the Machinery Hall interesting experiments with extra high pressure currents are daily shown to visitors. Alternating current at a pressure of 2,000 volts is obtained from a 450 H.P. dynamo, and transformed up to 20,000 volts. The transformers used are of two kinds, those with and those without oil insulation: the latter being enclosed with glass casing to keep out moisture. A collection of 200 100 volt glow lamps in series is mounted on a large screen on one side of the room to show that the required high voltage has been reached. The experiments with the 20,000 volt arc are very striking, and are similar to those described in *The Electrician* for May 22nd, where an illustration was given of the arc formed.

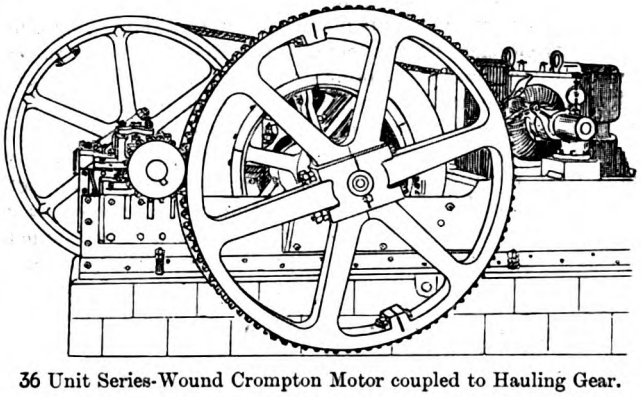
In the experiments seen by me, thin carbon pencils were used to draw out the arc, which usually broke down when the distance between the carbon points was about 6in., the flame of the arc being driven upwards by the hot air, rising to a broad, thick summit, and blazing with a hissing, crackling sound. Plates of glass were also placed between the two poles, and the voltage increased to piercing point. In order to show the phenomena of electric discharges due to electrostatic action, a number of glow lamps were joined to one of the high-pressure terminals of the transformer, and their glass globes put to earth by means of a common plate covering the tops of all. The discharges due to the potential difference between the glass globes and the lamp filaments (10,000 volts) were not brilliant, but could be distinctly observed.

From this department, also, a 20,000 volt current is transmitted for lighting purposes to the Exhibition on the Main. The transformer used is without oil insulation, and enclosed in a glass case to keep it dry, as already stated. The cable used was made by Siemens Brothers, of London, and was tested at the works up to 40,000 volts. The cable is not of the concentric kind, but consists of two cores of copper wire, ·12 inches thick, each protected with a very stout rubber covering, and then twisted into a spiral, and made up to a cylindrical section with jute serving, and finally covered with tape and compound. The cable is simply laid in the ground, and has stood well.

Messrs. Siemens Brothers, besides the above cable, have several other exhibits in the Electric Distribution Hall, and in the Marine Exhibition on the river. In the Hall are patterns of their sea cables, showing the different sizes used according to the depth, and a model of the cable ship Faraday, with cable-laying apparatus; and here are also samples of their lighting, telegraph, and telephone cables. In the Marine Exhibition they exhibit their system of submarine mining for the protection of harbours, &c.

AN ELECTRIC HAULAGE PLANT.

The electric haulage plant which was recently installed (see *The Electrician*, July 31, p. 351) at Abercanaid Colliery, for the Hill's Plymouth Company, in South Wales, shows that mining engineers in that district are beginning to appreciate the advantages of electricity.



36 Unit Series-Wound Crompton Motor coupled to Hauling Gear.

The winding gear was the usual form employed in the main and tail rope system. The motor is a Crompton series-wound machine, built to run at 600 revolutions per minute and take 80 amperes at 450 volts; at starting, when a heavier current is required, it will take 160 amperes without harm. The motor is placed horizontally at one end of a wrought-iron frame (see figure), which forms the bed for the drum and spur-wheel. The drum shaft, which is of steel, is driven from a counter-shaft by means of spur gearing, and the motor drives the counter-shaft by means of six 1in. ropes. The haulage engine is fitted with two drums, 3ft. 6in. diameter and 1ft. wide, which are controlled, as above stated, by clutch and foot-brake. This plant will haul coal from three different parts of the pit, and, although these are not far from the motor at the present time, it is expected that coal will have to be dealt with nearly a mile distant.

The generating plant comprises a Crompton compound-wound dynamo, having an output of 160 amperes at 500 volts

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when running at 550 revolutions. The cable connecting the dynamo with the haulage plant is 3,200 yards long, and composed of 37/14 copper wire, insulated with vulcanised bitumen. It is protected by a double sheath of No. 8 steel wire, the first stranding being of 30 wires, and the second 36 wires, laid in reverse directions. The cable is carried down the level by the side of the shaft, and between the hauling engines it is fixed on each side of the roadway, and, in case of "falls," the cable has been constructed so that it can stand a shearing strain of ten tons per square inch.

A number of visitors were invited by the Hill's Plymouth Company to see the opening ceremony. The engineer to the Company, Mr. Bailey, stated that his father had put down the first system of rope haulage for mines 30 years ago, and the electric system of haulage now inaugurated would enable the Company to increase its output very considerably. The compressed air system was very costly, and they were thrown on their beam ends, as it were, when Mr. Howell, of Llanelly (Messrs. Crompton's agent) offered to supply this electrical plant. They found that the capital required was only half that for compressed air, while the latter only gave 30 per cent. efficiency, electricity gave 65 per cent., which was a most important improvement. He added that he placed perfect reliance on Mr. Howell's estimates and working, the more especially as since Mr. Howell had erected their electric lighting arrangements at Abercanaid they had never had one hour's stoppage, which spoke well for the machinery and for Messrs. Crompton's work. They found it impossible to go on with horses, and were glad that they had put down an electric haulage plant, and would have great pleasure in showing and explaining it to any others interested in such matters.

THE CAUSES OF VARIATION OF CLARK STANDARD CELLS.*

BY J. SWINBURNE.

It is well known to those who have worked with them that Clark standard cells are not yet to be trusted in very accurate work. It is quite easy to make up a few cells which agree among themselves, but they seldom agree with others made up at different times with different chemicals by different people, and they often take long to "settle down." No one who wanted a standard within less than one-tenth per cent. would set up a Clark and trust it without comparing it with other cells. The measurement of electromotive forces can easily be made within not only one in a thousand, but one in a million, and, as we already have accurate resistances, a standard cell giving even approximately accurate results would be of enormous value. It, therefore, seemed worth while to investigate the causes of variation of Clark cells. The Clark cell has already received the most careful attention from Mr. Latimer Clark and Dr. A. Muirhead, who has, I believe, already gone thoroughly into the chemistry of it; and from Messrs. Wright and Thomson. Lord Rayleigh has, perhaps, gone into the matter more carefully than anyone else; and Messrs. Carhart, Dearlove, Skinner, Fleming, Crompton and very many others have worked at the same subject.

The method I have followed is to take the various parts of the cell separately, beginning at the zinc and eliminating the rest of the cell.

The cell taken as standard throughout most of this investigation was made in strict accordance with the latest Board of Trade Committee's circular. Two were made at the same time, and one, No. 1,614, was sent to the committee, while the other, No. 1,615, was kept for reference. My arrangement for measuring electromotive forces would read about 0·000002 of a volt. Cell No. 1,615, or, as I may call it for reference, the B.O.T. cell, was always kept in the water bath, in which all cells under examination were left. All the apparatus was insulated by being fastened to celluloid plaques fastened to the wall, or by standing on celluloid mats.

* Abstract of a Paper read before the British Association, in Section A, at Cardiff, August, 1891.

Variations due to Zinc.

The following zincs were tried:—1,620 and 1,625 from Townson and Mercer, labelled "free from arsenic"; 1,621 "pure," from Hopkin and Williams; 1,622 Becker's second quality, 1,623, roofing zinc. These were first filed and sand papered, washed in caustic soda, dried with filter paper, washed with dilute sulphuric acid, and then with distilled water. These zincs were suspended in a carbonic acid flask in a saturated solution of zinc sulphate which had been shaken up with barium carbonate and filtered. I need not give the tables of readings of these zincs. At first they varied about 0·4 per cent. The variation increased to more than half per cent. Sometimes one zinc was higher, sometimes another, and on shaking the flask a little the readings were altered. The zincs were cleaned again and dipped for a moment in a weak solution of acid mercuric sulphate and washed. They were thus very slightly amalgamated. After an hour the zincs came within about four in a million. One of them, 1,625, was then thickly amalgamated by dipping in acid mercuric sulphate. Drops of mercury hung to it. It read 0·999910, 0·999976, 0·999988, and finally one in the course of two minutes. The zincs were then put back into solution 1,624, which gave so much trouble before. They now read within one or two in a million. After standing for nearly three weeks they were marked all over, and varied nearly a tenth per cent. among themselves, and more than that compared with 1,621, which had been in another solution acting as a standard in other experiments.

From this it appears that in order to give good results the zincs should be heavily amalgamated. If thoroughly amalgamated practically any zinc will do. The zincs which gave low electromotive forces were always the small ones, that is to say, those which would get the thickest coatings of iron.

To find out whether amalgamating altered the readings an amalgam was made by touching mercury with zinc. It was more than a half per cent. wrong. After dissolving more zinc, the reading was still low, though by stirring in zinc it soon came up to 0·9984 and 0·9994. A series of amalgams was made, containing 25, 12½, 5, 2½, and 1 per cent. of zinc and one with less zinc. These were put in solution 1,628 of zinc sulphate with little iron. The solution was poured in and out many times to secure homogeneity, an important matter to which I will return. The readings obtained were—

25 per cent.	1·000025 and	0·99999
12½ „	1·00008 „	1·000000
5 „	1·000035 „	1·000010
2½ „	1·00005 „	1·000020
1 „	0·997225	
trace	below 0·995	

The second readings, which were taken a few minutes later, are close enough. Amalgams, therefore, having some 2½ per cent. of zinc will do.

Lord Rayleigh has done a great deal of work on amalgam cells, and he found the amalgam always cracked the tube. I made one H cell with amalgam in 1888, which had the platinum led out at the bottom, but it did not crack. I made several other cells at the same time with an internal test tube to hold the amalgam, and none of them cracked. On the other hand the 5 per cent. amalgam broke its test tube. I would suggest that platinum sealed to German glass is always left under constraint, and the crystallisation of the zinc also adds pressure which cracks the tube. My H cell had a little lead glass just round the platinum; moreover, it was very small. The 2½ per cent. amalgam is liquid, so there is no danger from it.

The Zinc Sulphate Solution.

The chief difficulty arises from the presence of iron. Samples were bought from Messrs. Hopkin and Williams, and Becker. These both contained iron. When I say that samples of sulphate of zinc bought as pure from such people as Messrs. Hopkin and Williams contain iron, I mean that they contain enough to cause variation in cells, not enough to get precipitates of Prussian blue. The best method of dealing with iron is to acknowledge its presence and amalgamate the zincs. The best

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zine sulphate solutions I used were obtained by dissolving granulated zinc in dilute commercial acid, keeping the zinc in excess.

In order to test the effects of various solutions of zinc sulphate, test-tubes with feet were filled with the solutions, and were connected with the standard solution by a siphon tube. This had one end blocked with filter paper to prevent mixture of solutions. It is needless to give tables of readings. Anomalous results were obtained at first, but they were all traceable to the zincs. After amalgamation all the saturated solutions gave the same readings within a few in a million. 1,621, made by dissolving pure zinc in acid, was 100 in a million too low.

To test the effect of acid I added a few drops of "normal," that is, very dilute sulphuric acid, to a saturated solution of Hopkin and Williams's zinc sulphate. Free acid appears to make little difference.

The solubility of zinc sulphate varies enormously with the temperature. If a tube of it is left with crystals collect at the bottom, when it comes to a low temperature all the crystals at the foot. When the temperature rises the upper part can only become saturated again slowly by diffusion. To test this, two zincs were put in a test tube of saturated solution with crystals at the bottom. After a few days the top zinc gave 1·0005 compared with the bottom. The lower zinc was then raised, reading 1. The other zinc was then depressed, reading 0·999475. The difference of density thus causes an error of 5 in 10,000. This tube was 10cm. long, so the error in standard cells may not be so great as this; still diffusion is very slow even in a short cell. This also influences the temperature coefficient. The question of supersaturation has already been dealt with so thoroughly by Lord Rayleigh that I saw no use in experimenting on it.

To sum up, the chief errors caused by the solution are due to traces of iron and variations of density. The zinc should, therefore, be amalgamated. I would suggest that zinc carbonate be omitted. To avoid changes of density, if a saturated solution is imperative, a zinc amalgam must be employed with crystals lying on its surface. This can be done in one of Lord Rayleigh's H cells, or a smaller tube can be slipped into the cell. The surfaces must be on the same level, else all the crystals will collect on the lower one, as that lowers the centre of gravity of the system, thus doing work. A small test tube full of crystals was put inside a larger tube of saturated solution, and this action was found actually to take place.

There is some further complication between the zinc and its solution. Even amalgams will give very large variations if moved about in the solution. This is the case even with dilute solutions. I can scarcely hazard a suggestion.

Mercurous Sulphate.

Samples of mercurous sulphate were bought from Messrs. Becker and Hopkin and Williams. I also had some samples from Hopkin and Williams, Becker, and Griffin, bought in 1888, and some I made myself at the same time. I also prepared some new specimens by heating in an oven a flask with mercury twice distilled in vacuo and redistilled acid. The temperature was kept at 125°C. by a mercury regulator, and only a portion of the mercury was dissolved. The sulphate was washed with distilled water and dried. It is in white crystals. Other samples were made by dissolving mercurous nitrate in water slightly acidified with nitric acid, and precipitating with zinc sulphate. This is perfectly white unless much washed. A yellow colour then appears.

In testing the pastes, some of that used for the B.O.T. cells was used as a standard. Zinc No. 1,621 was kept in a solution of sulphate, and was connected by a syphon with the tube of standard paste, the cell thus made being checked against the B.O.T. standard. After a few days there was never any deflection. The cells seem to tend towards a common value, but that is almost all that can be said. The Board of Trade circular directs the paste to be rubbed up with mercury. This would tend to reduce the persulphate to protosulphate. Mercury cannot be rubbed up with protosulphate, as it does not oxidise the surface, so the mercury is not "killed," and collects in a globule. The mere fact of the mercury mixing shows that the sulphate is bad.

Mercury.

To test the effect of impurities, some amalgam, containing silver, copper, and zinc, was taken. Sodium amalgam was added, and the whole shaken up with salts of lead, iron, antimony, platinum, and tin. The amalgam was then shaken up well with persalts of mercury. The mercuries to be tested were put in little crucibles in a solution of mercurous nitrate. After a few minutes they all agreed.

Temperature Coefficient.

The temperature coefficient of several cells was taken with some care. The following readings were taken, the temperatures being kept nearly constant by adding hot water:—

1,680	0·000287	1,685	0·000492
1,682	0·000421	1,688	0·00085
1,683	0·000324	1,689	0·00042
1,684	0·000756		

Of these cells, 1,680, 1,683, 1,689, had dilute solutions made up of equal weights of water and $ZnSO_4 \cdot 7H_2O$. 1,680 and 1,683 differed only in the mercury; 1,683 gave different coefficients on the two days. The variations in the other cells may be easily explained. If a cell with the zinc at the top has its solution saturated at, say, 15°C, and is then heated, the solution round the zinc is no longer saturated. The temperature coefficient of the cell depends on its past history, in fact, and is lower in spring than in autumn. An H cell, or a tube cell, with crystals of zinc sulphate in contact with the zinc always has its solution saturated at both plates. 1,682 is

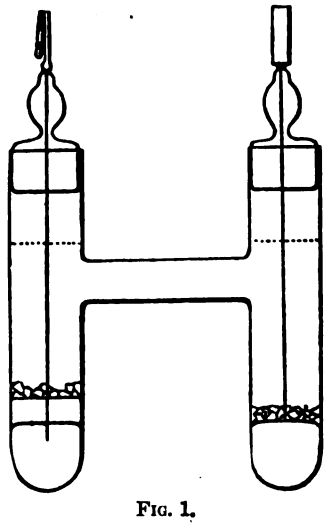

Fig. 1.

an ordinary cell, but the zinc is at the top, hence its low temperature coefficient when heated. If left at 30°C, for a few weeks, and then cooled, no doubt its temperature coefficient would rise to 0·0008, or 80. 1,684 is an H cell, with crystals in both legs. 1,685 is an electrolysis cell, with zinc at the top. 1,688 is a tube cell, with crystals in both tubes, hence its high coefficient. It is thus clear that the temperature coefficient of a cell may vary from day to day according to its treatment, and may, perhaps, vary 100 per cent. between winter and summer. Even a variation between ·0008 and ·0006 means an error that may, in extreme cases, amount to something like a half per cent., that is, it may be outside the limits I have here taken as worth considering. My water bath differed some two or three degrees from one evening to another, and, no doubt, varied more during the day and night. A new cell would thus be saturated at, say, 20°, while the standard was saturated at, say, 15° If the coefficient of one was 0·0008 and of the other 0·0004, the error might easily be 0·0012 due to that alone. To avoid this difficulty the solution must be kept saturated by using the H or tube cell. Some authorities push the zinc into the paste. This may give the same result, but the zinc then amalgamates too much. It would seem better to use a weaker solution. Prof. Carhart and others have proposed saturating at 0°C. It seems much simpler to use a standard solution of sulphate made by weighing.

The construction of the H cell is shown in Fig. 1. One leg contains amalgam with crystals on it, and the other paste.

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Platinum wires are sealed through glass stoppers, and end in little bracelet snaps. The stoppers are smeared with vaseline to prevent creeping. Fig. 2 is a tube cell. A test tube with a foot has a cork with two holes in it. Through one of them the tube with internal wire is led to the bottom. The mercury and paste are poured in through a funnel. The zinc tube is then pushed through the larger hole in the cork; it contains the amalgam, and has three holes in the side. It is strong to resist fracture. Solution is poured in gently over the level of the first hole. Rangoon oil is poured in above the level of the second hole. The third lets the air out. The zinc connection is then put in, with its cork fitting the smaller tube. If the solution is saturated, the inner tube must be long, so that the zinc surface is on a level with the crystals on the paste. If a dilute solution is used, the inner tube is shorter. This form of cell is convenient for immersing in a bath, and the zinc tubes can be taken out and changed, or tried in other cells. Though tube cells with dilute solutions and pure mercurous nitrate agree within one in a hundred thousand, it is desirable that such cells should be made up by different people. The questions of the methods of making up standard cells should, therefore, be taken up by a committee.

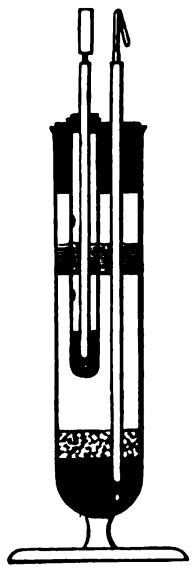

Fig. 2.

Prof. Carhart mentions the effect of pressure on Daniell cells. I tried exhausting a Clark cell a third of an atmosphere, and raising its pressure, but though that must have affected the tendency of the liquid to evaporate, it made no perceptible difference in the reading.

THE BINSWANGER-COATES MICROPHONE.

Messrs. Binswanger and Coates, of the General Electric Company, have recently brought out a microphone which, they claim, possesses the advantage of the vertical form of diaphragm, and also that of being worked best by a single cell. The diaphragm is clamped to the box by means of two brass clamps, without the use of india-rubber. The carbon tension regulators consist of two blocks and two pencils; the blocks are so made that they are clamped to the diaphragm by one screw only, and yet present an angle of about 45deg. to the vertical form of the diaphragm, as shown in Fig. 1. The space between the carbon blocks and the diaphragm is filled by cork, and forms a damping arrangement not influenced by atmospheric changes nor by vibrations—such as, for instance, passing trains in a railway station. Owing to the disposition of the carbon pencils upon the blocks, the vibrations of the diaphragm are transmitted in such a manner that the loose carbon pencils are influenced by gravity alone, and the rolling effect of the pencils, causing that burring and indistinct articulation of pencils in a vertical position alone, is obviated. This position of the cork damper, together with the fact that the vibrations are transmitted from the diaphragm to the carbons by means of two screws only, fixed almost in the centre of the diaphragm, allows the vibration of the diaphragm ample play and full force, so that speech is reproduced not only very clearly, but with increasing loudness.

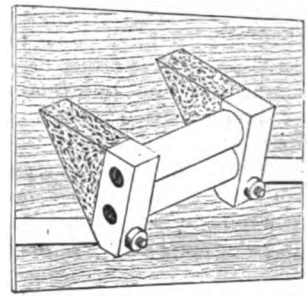

Fig. 1.

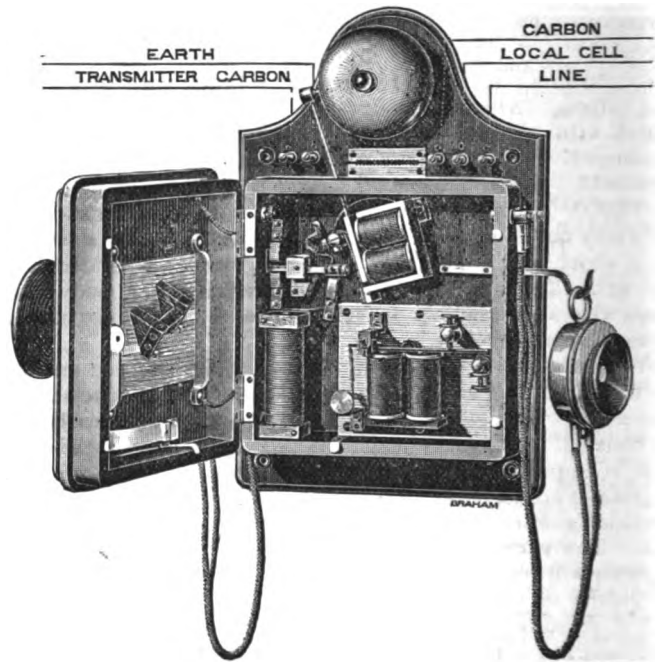

Fig. 2.

A number of railway companies have found these advantages suitable for their purposes, and we illustrate in Fig. 2 a set specially designed with long distance relay for the bells for use in signalling on railways.

RECENT PROGRESS IN THE USE OF ELECTRIC MOTORS.*

BY PROF. G. FORBES.

In the application of electric motors I have noticed three directions in which this country needs the testimony of independent and impartial people to assert the value of applications which in some other countries are generally adopted. These are:—(1) Electric railways. (2) Replacing shafting in shops by electric conductors and motors. (3) Transmitting power to a distance from waterfalls and rivers by electricity.

Electric Railways.—These are thoroughly established in America on the cheapest system, *i.e.*, electricity supplied from a central station by overhead wires. The extensive adoption of electric tram lines in America, and the small number in England, is certainly due to the fact that they allow these overhead conductors, and we do not generally do so. The most trustworthy estimates seem to vary between 4·18 and 6·00 cents per car mile, including coal, attendance, land and buildings, machinery, line, oil, water, and waste. The question of repairs is serious and must be reduced. Most of the lines adopt spur gearing to reduce the speed from the electric motors to the car axles. They generally use two pinions and two spur wheels. This introduces great friction. It is very generally

* Abstract of a Paper read before the British Association, in Section G Cardiff, August, 1891.

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accepted that 8 H.P. is lost in gear friction, though this seems somewhat incredible, being about 30 per cent. These cars are large, and the motors are of 30 H.P. This enormous power is absolutely demanded to enable them to start on a gradient with facility, and they do this. There is no crawling about these cars. You feel that there is plenty of power for the work. The noise in these cars used to be very considerable, and the injury to watches through magnetisation was at one time an objection. The noise from the gearing, especially when worn, has been deadened by enclosing the motor and gearing in cast-iron boxes. The magnetisation of watches is prevented by adopting a suitable type of motor. Another source of trouble in motors used to be the brushes, for sparking is liable to be very violent with the variable load of a tram motor, and the commutators wore away rapidly. Since carbon brushes have been introduced this difficulty has entirely disappeared.

The loss in double reducing gear and the wear and tear led to all the important companies turning to single reducing gear with rather heavier motors. It would at first appear impossible to go farther, and adopt armatures on the wheel axles without sacrificing the great advantage of gearing, which allows the motors to be independently supported without being subjected to the same shocks as the wheel axles. In spite of this, the Westinghouse Company has introduced a gearless motor, which has strength enough to stand the shocks. But other inventors had the idea of fixing the armature alone on the axle, and supporting the field magnet wholly on springs; to support it partially on springs is of little value. In this direction the most important and promising plan seems to be that adopted by Eickmeyer and Field. They support the whole motor in guides on springs, and connect the motor axle and the wheel axle by cranks and a coupling bar, the cranks on the right and left sides being at right angles to each other. This seems to reduce gearing friction to the minimum, while completely obviating shocks.

In America spur gearing is almost universal, but in Switzerland the Oerlikon Company are introducing worm gearing, which has been so much approved by Mr. Reckenzaun. Storage batteries have not generally been successful in America, but in some trials have worked very well.

Replacing Shafting by Electricity.—The benefit of replacing shafting by electric conductors and motors has been thoroughly appreciated in America. Everyone knows of the hundreds of motors for small work which are supplied with electricity by central stations in Boston and New York, besides other places, and of the large number of electric lifts supplied by the Otis Company with electric motors designed by Eickemeyer. I will only place before English manufacturers two of the establishments where a statement of what has been done is enough to bring conviction to the mind of every shrewd and sensible employer of power. In the great works of William Sellers and Co. shafting has been abolished as far as possible. The second establishment is Baldwin's locomotive factory, whence from 16 to 20 locomotives are sent off every week, and where space is so far valuable that there is no room for shunt lines, and where a 100-ton travelling crane picks up one out of the 20, and puts it down where wanted. This fine travelling crane, and every other crane in this huge part of the works, are driven by electric motors.

Transmission of Power to a Distance from Waterfalls.—With regard to transmission of power to a distance from waterfalls, I have seen little to chronicle in America, and what there is seems rather antiquated; but in Switzerland important work has been done both by continuous and alternating currents. The high tension electrical work in connection with continuous currents that most impressed me was what has been done by Cuenod, Sautter, et Cie. Their six-pole machines, with Gramme commutators up to 2,000 volts, designed by M. Thury, seem to work admirably and sparklessly, and I must here state my conviction, which I did not previously hold, that the insulation of such a machine can be made perfect, as there done, by supporting the dynamo or motor on a number of alternate slabs of vulcanised rubber and porcelain, and by connecting the shafts by Raffard couplings.

I will not take up time with describing different works of this kind, but I will now say something about the use of multiphase alternate, or rotary currents, about the prospective use of which so much has been published. I have seen the machines and transformers in course of construction at Oerlikon, and the insulators which have been used; the mechanical design is excellent. I can quite appreciate the difficulties of regulation of three currents referred to by M. Dobrowolski, but I think that there are further points upon which information is much wanted. I want to know, for hitherto I have utterly failed to see, the advantage of this three-phase synchronising alternator over the simple alternators which do such excellent work. I have been told that calculation shows that Mr. Brown's machine has 96 per cent. efficiency as a dynamo. Well, I reply that an ordinary alternator without iron, not having the hysteresis of Mr. Brown's machine, ought to have a higher efficiency, In the next place I am told by Mr. Brown that while you cannot switch one of these three-phase synchronising motors, with its load, on to an electric circuit, and expect it to get up to the synchronising speed, yet it will do so along with the electric generator of electricity, if the latter be also started from rest. In this it certainly has the advantage over the synchronising alternator with iron, but none whatever over those without iron, which will act in precisely the same way unless the motor happens to be stopped on dead centres, *i.e.*, with the centres of coils (in a Mordey alternator, for example) half way between the poles of the field magnets. If this is the only gain over single phase alternators with self-induction, and if there be no advantage gained over alternators without large self-induction, I fail to see the merit of the complication of three phases. I would not have drawn attention to the absence of advantage, but would have preferred to await the experiments before expressing an opinion, were it not for the great attention directed to the scheme by the Press, altogether out of proportion to the results which Mr. Brown and the Oerlikon managers hope to obtain. The great experiment about to be tried at Frankfort, which interests electricians all over the world, is not to prove that transformation is efficient, but to prove that 30,000 volts can be carried along 112 miles of overhead conductor.

M. Dobrowolski says that whatever load may be put on his motors, there is no serious difference in phase between the poten tial difference applied to the motor and the current, and there is no appreciable lag. If this be so, it would be a decided improvement; but I shall require strong proof before I accept the multiphase motor as a great advance over the Tesla machine. The only advantage which it possesses over synchronising alternators without iron in the armatures and with large momentum, lies in its power to start with the load on. But I do not see that in large applications this advantage is to be compared with what it loses by its want of synchronism. M. Dobrowolski claims that these machines have the further advantage over the synchronisers that they will not stop when overloaded. After having tested Mr. Mordey's synchronising alternators, I have a strong conviction, almost amounting to a feeling of certainty, that it is impossible to put them out of step in ordinary conditions by merely increasing the load. The more you increase the load the more current goes through them to keep them in step. They would rather get red hot than get out of step. They behave just as a continuous current motor or Tesla motor, or a Dobrowolski motor, behaves under the same conditions; it gets hot, but it does not stop.

People seem to be greatly at a loss to explain why it is that some alternators work well as motors, while others do not. The explanation is simply that the former have a large momentum, and the latter have not. I announced this explanation of the difficulty at a meeting of electricians in Paris, last February, and found that M. Hospitalier had arrived at exactly the same conclusion, and quite independently. I feel confident in predicting that the Ferranti dynamo, if supplied with a heavy enough fly-wheel, will be found to work as well as the Mordey machine as a motor.

BRITISH ASSOCIATION.

UNITS AND THEIR NOMENCLATURE.

On Tuesday, last week, a joint discussion took place on the above subject in Sections A and G, under the presidency of Dr. Oliver Lodge.

The PRESIDENT, in the course of his opening remarks, stated that he thought that in the beginning they had better confine themselves to electrical units, and leave the more academical and mechanical until a later period. One of the most pressing points in connection with electrical units was the want of an authoritative statement of the coefficient of self-induction and of mutual induction. Many names had been suggested for this unit, *secohm* and *quadrant* for instance, also that it might be named after some man. The name "secohm" had its advantages and its disadvantages. It expressed the unit of self-induction as derived from the ohm, but the ohm itself was based upon self-induction. If it should be called a quadrant, it must be remembered that a quadrant was an angular measure and it had the disadvantage that it pretended that the thing was a length when it was not a length. He thought they would make a mistake if they fixed it for all time as a length. Some name with a less obvious meaning was desirable, such as that of a man. Was the secohm a convenient size? The C.-G.-S. units were a connected system before any practical units were invented, and were of quite the wrong size for practical engineers. Very few people, he thought, had to deal with coefficients of induction of more than a secohm; this statement he made subject to correction. Would it not be better to make the practical unit some submultiple, $\frac{1}{10^9}$, or something of that sort? The next unit was either the unit of magnetic field or the unit of magnetic induction. There was a C.-G..S. unit of magnetic field which had not yet had a name given to it, but it was too small for engineering purposes; moreover, the definition of the unit was not one which immediately applied to practical engineering.

Mr. W. H. PREECE remarked that the work of the British Association Committee on Electrical Standards had extended over thirty years. It

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was first formed in 1861, at Manchester, and with much difficulty and trouble they had succeeded in impressing those units over the whole world. During the last year a Committee appointed by the Board of Trade had been considering this work of the British Association, with the result, probably, that steps would be taken to make the ampere, ohm, volt, and so on legal standards. Having worked many years to achieve this result, he was afraid that the British Association would be running its head against a brick wall if it attempted to upset the system it had established; nevertheless, he intended to suggest a change. There is a difficulty in pressing new names into our language, yet new names must be invented to describe new things, and he was a great advocate for the use of words based on the names of the great departed; it was a method of paying a graceful tribute to their memories. Such names sometimes prevented great difficulties, preventing mistakes, for instance, such as those sometimes made in distinguishing power and work. Such words as Watt and Joule never cause confusion. He thought that the names of living persons should not be applied to the units. The time had come when a unit of magnetic force must be adopted. There was once a demand for a unit magnetic pole, but that time had passed. Two great quantities were most important and required much attention; one was the μ and the other k. He always spoke of L, the coefficient of self-induction, as "electro-magnetic inertia," and he wished that they had a unit for that term; he thought that a good name would be *henry*. He thought that the name of Gauss should be applied to a unit; a new table of specific resistances should be made; a new determination of J, the mechanical equivalent of heat, was also wanted. They required to get rid of that useless table of dimensions which encumbered every text book and engineer's pocket book, and they wanted dimensions based on some physical fact. He should be sorry that any decision come to that day should interfere with the old standards now about to be legalised, especially as in 1893 there would be an Electrical Congress in Paris, which would have to adopt our legalised standards, so that, in the end, the British Association electrical standards must become those of the world.

Prof. W. STROUD then read a Paper entitled "Some Revolutionary Suggestions on the Nomenclature of Electrical and Mechanical Units," of which Paper the following is a summary:—

The Present Practical System of Units.—The present practical system of units is very objectionable on these grounds:—(*a*) There is no *primâ facie* reason why the practical unit of current should not be equal to the C.-G.-S. unit. (*b*) The relation between the other practical electrical units of the corresponding C.-G.-S. units is much more complex than need be. (*c*) The units of work and power are far too small for practical requirements. (*d*) If we were starting to devise a practical system to-day, such a system could best be formed by 10^9 cm. as the unit of length, 10^{-9} gr. as the unit of mass, and one second as the unit of time. (*e*) That in the interests of the practical men of the future, and in the interests of the electrical students of both the present and the future, it is highly desirable to initiate a revolution, with the object of dethroning the present practical system of units.

Nomenclature.—(*a*) That the term Dyne, to indicate 10^7 of our present (1891) dynes, is objectionable, as custom has restricted the use of Greek derivatives entirely to C.-G.-S. units. That 10^7 dynes, *if required*, should be called a hebdomadyne, suitably contracted, of course. (*b*) That the classical languages are of little or no service for the provision of names for modern, more or less complex, physical conceptions; and, therefore, this method of coining words it is desirable to abandon. (*c*) That for C.-G.-S. units some system of *automatic nomenclature*, in which every name shall be self explanatory, would prove a boon to the teacher and a blessing to the student, and that such a system is quite capable of being devised. (*d*) That the prefixes *meiza* to indicate 10^9 and *mei* to indicate 10^{-9} may be found useful.

Mr. SWINBURNE thought that they had better stick to the old standards as long as possible, especially as great difficulties are thrown in the way of practical people by the making of changes. He did not think that the idea of self-induction would ever spread much among those engaged in practical work. He hoped that the name of Poggendorf would not be left out from those applied to units.

Dr. G. JOHNSTONE STONEY would like to see the old system maintained intact. He was a member of the original committee which fixed the C.-G.-S. system, and it was pointed out at that committee that no system could be proposed which would not in some cases be too large or too small. Some notes in Prof. Everett's book about his (Dr. Stoney's) opinions on units did not express his opinions at all. He thought that the proper way to deal with the subject before the meeting was to introduce a nomenclature which would indicate multiples and submultiples, as had been done in spectroscopy, and to let practical men select numbers most useful for their purposes. For instance, the microfarad he would call the sixth farad, and it would do for cables; the $\frac{1}{10}$th farad would act for the Leyden jar. Why not have a nomenclature to indicate in each case what was being used? All the measures employed should belong to some definite system. He thought it to be a great misfortune that, as they had just heard, persons engaged in making transformers could not tell what self-induction was, for it would be well that every artisan should know what he was about. He was averse to any revolutionary change in the standards; although he did not think the C.-G.-S. system to be the best, he should be sorry to see any great change in it now. The speaker then showed to the meeting a table of the relations between electrical units.

Continuing, Dr. STONEY said that he thought that the name for the unit of magnetisation should be *gilbert*, and that of the unit of magnetic field should be *gauss*. Weber's name should be brought in, but the difficulty would be that some persons would give it its German pronunciation of Veber, whilst others would call it Webber. The table he had produced was intended to be used merely for conversions, and not for introducing a new system of measures. He thought that the time had come to get rid of the word "force" as applied to that which is only one factor of a force; potentials should be called force factors. Why not speak of these all as energy factors? The word "pressure" was very misleading, and he thought that "voltage" should be substituted.

Prof. CAREY FOSTER was glad to hear Dr. Stoney's conservatism in the matter of the units which have proved so useful; if they were to begin the work over again they would always be uncertain what they meant by their names unless a special adjective were appended to them. Still, they wanted a volt and an ampere ten times as great as those now in use; some name connected with Galvani, "*gal*" for instance, might be given to one of them, and another word found to represent ten amperes.

After a few remarks from Prof. RUCKER,

Prof. SILVANUS THOMPSON said, in relation to the unit of self-induction, that Dr. Lodge had stated that he did not see why its coefficient should be considered as a length, but it *was* a length, and Sir William Thomson had devised an ideal experiment illustrating the point. They needed that a physical fact should be discovered to enable them to determine the absolute value of k or μ.

Prof. ANDREW GRAY thought the phrase "electromotive force" was unfortunate, but that it would cause much inconvenience to drop it. A clear distinction, ought, however, always to be made between *electro-motive force at a point* (that is the *electric force*) and the electro-motive force round a circuit. It would cause serious confusion if one word were used in two senses; if the word "force" were not used alone, but described at the time of speaking, he thought that not much disadvantage would arise. He trusted that more attention would be given to what was of greater importance than finding a name for the unit of inductance, *viz.*, the calculation of coefficients of induction.

After a few remarks from Prof. D. E. JONES,

The PRESIDENT stated that time would not allow the continuation of the discussion; he hoped that it would be continued in the journals, especially as at present it was not quite clear what was actually wanted in practice.

Mr. PREECE thought that it would be objectionable for the British Association to suggest any change in the principle of the unit. The farad was as immense as the universe, and the microfarad very small, but useful; he thought that it would be well to call the microfarad the farad, and that they should call the volt and ampere either the ten-volt and ten-ampere, or the *weber*.

Mr. W. MOON contributed a Paper which was taken as read, and which set forth the disadvantages of the C.-G.-S. system, the units of which were so small that one could form no conception of their value, and that, owing to this smallness, it was necessary to introduce a separate set of practical units for ordinary purposes of measurement. These disadvantages might be overcome by taking as fundamental units L and M larger, or T smaller. Of all the systems of metrical units that could be formed by varying L and T by multiples or sub-multiples of 10, that system was the best which was founded upon the "decimetre, kilogramme, and decisecond." If the name "instant" were given to the decisecond, the system could be spoken of as the D.K.I. system. In the D.K.I. system, "g" = 981, or nearly unity, so that the weight of a kilogramme could be taken as the unit of force for rough calculations. This would be a great improvement, since the simplest way to conceive a force is as the weight of unit mass. A prepared table showed that all the D.K.I. units were sufficiently large to be used for practical purposes, and that all the multiples and sub-multiples of them that would be required could be expressed by the usual Greek prefixes to their names. To express the large numbers required for insulation resistances, and the small capacities of condensers, the Greek prefixes, "Omega" and "Omicra" might be used for powers of 10^{12} and 10^{-12} respectively.

TANNING BY THE AID OF ELECTRICITY.*

BY DR. S. RIDEAL AND A. P. TROTTER.

The slow rate at which a hide is converted into leather in the ordinary process of tanning has induced many inventors to devise methods by which the chemical change might be accelerated without deterioration of the quality of the leather produced, but the want of any definite knowledge as to the precise nature of the interaction which takes place between the gelatin of the raw hide and the various tanning employed in this industry has been a serious obstacle in the development of these methods, and many of the proposals after having been tried on a small scale have been abandoned in favour of the old and slow process. It is necessary to refer to some of these proposals in order to understand the position of the industry a few years ago, when the first important steps towards the employment of electrical energy for hastening the tanning process took place.

One of the earliest patents for accelerating the process of tanning by mechanical methods is that of Francis G. Spilsbury, of Walsall, Staffordshire, and is dated 1823. He used oblong frames of wood and stretched the hides on these, placing a frame between, and thus forming a vessel, having stretched hides for its sides. Into this vessel the tanning liquor was run through a pipe from an elevated tank, pressure being regulated by the hydrostatic head. The hides became distended and the liquor oozed out, forming drops like dew. By this process it is said that the hides could be tanned

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in six weeks, or in some cases in eight or nine days, instead of a year. The process was abandoned owing to the trouble entailed in closing any holes or tears in the hides and the considerable waste caused by cutting the hides to fit the frames. Another early invention for hastening tanning was that of T. J. Knowles, who employed an air-tight vat. The hides were suspended in the liquor from hooks at regular intervals, and were provided with leaden weights to keep them uniformly stretched. The air was exhausted by a pump, and after an interval the liquor was removed and the air admitted. This process was repeated until the tanning was accomplished.

One of the first applications of mechanical motion was that of W. Brown, of New York, who employed a reel or cylinder, composed of two heads and a number of longitudinal bars, with pins on the outer surface on which the hides were fastened. He also threw them loose into the cylinders, which were slowly rotated by means of ratchet gear. In America, a rocking bar was used, the hides hanging from it and alternately dipped into the liquor and withdrawn from it. A modification of this consisted of a frame moving up and down, dipping the hides in the vat. These and other mechanical methods were used for the simple purpose of obtaining a continually fresh application of the tanning liquor to the surface of the leather, instead of the ordinary daily handling of the hides. These mechanical processes may be broadly divided into two classes: those in which the hides are allowed to hang or are stretched on frames, and those in which they are rolled or churned loose in bulk. In the former class, the stirring of the liquid is practically as efficient as in the latter, but there is no tendency to remove the soluble or soft gelatin and albumen by kneading and churning, and the hides being always surrounded by the liquor the tannage proceeds uniformly in every part.

So far the mechanical processes are designed for an obvious purpose, but when we come to the application of electricity to tanning, we find that the inventors are groping in the dark, using a powerful operator, but with no rational principle or motive. The only *à priori* reasons for applying an electric current to a hide in a tan pit are, that some electrolytic action *may* liberate some tanning agent in a nascent state, and that dialysis is accelerated by the passage of a current, and that there is a relation between osmosis and electrolysis.

As early as 1849 a tanner named Crosse proposed to utilise "electricity or galvanism for tanning purposes." The electrodes consisted of sheets of zinc and lead, immersed in an ordinary tan-pit in which water and the hides were placed, bark or other tanning material being added from time to time, after the skins had been subjected to this action for some days. Ward, in Lancashire, some years later, passed a current of electricity through the tanning liquor in ordinary tan-pits. In 1861, Rebu made several experiments on electrical tannage, employing various metallic salts as well as ordinary liquors in his pits. In 1874, de Meritens, of St. Petersburg, turned his attention to the subject, and has for some years adopted in nearly 600 pits the following plan of electric tanning. A layer of carbon connected with the positive pole of a dynamo is placed at the bottom of each vat, and it is then filled with the alternate layers of moist skin and tan, a plate of zinc forming the negative pole at the top of the pit.

In 1876, Lucien Gaulard and Kresser proposed another process in which they used two parallel plates of carbon, and immersed the hides between them in tanning liquor, passing a continuous current of electricity through from plate to plate. Leather made by this process was exhibited in London in 1883. The process of Landin and Abom has been worked for more than two years in the tanyard of Messrs. Nielson, of Norrköping, in Sweden. Here the hides are attached to wooden frames, and are placed in a pit. Large copper electrodes are provided, and an alternating current is passed.

A simple combination of motion and electrical treatment was patented in France by Worms and Balé in 1887, and consists of a large drum, some 11ft. in diameter, mounted on a horizontal shaft, and filled one-third full of tanning liquor, together with some turpentine, and in this half a ton of hides are placed loose in bulk. The drum is set in motion by steam power, and current of about 10 amperes is passed through the contents by means of copper electrodes placed on the interior surface of the ends of the drum. Nicholson and Palmer (Eng. Pat. 9776, 1889) have also described a similar process, in which the hides are suspended on the positive electrode within the rotating drum, and the current of electricity is caused to flow mainly through the hides.

Another distinct process is to be found in the Groth system of tanning, a description of some of our experiments on which forms the subject of the present communication. In Groth's apparatus there is a combination of motion and electrical treatment, but the motion is of such a nature that the hides being left stretched and suspended in the liquor are not churned about or rubbed one on the other, as in Worms and Balé's process.

The two practical forms in which Groth's invention has been worked at the Grange Works, Bermondsey, are, first, a round vat containing a revolving frame carrying the hides, and, secondly, a rectangular tank in which a similar frame is carried to and fro, running on wheels, and moved by a crank. One of the circular vats placed at our disposal was 7ft. 3in. in diameter and 6ft. 4in. deep. The cubic contents were thus about 315 cub. ft., or nearly 2,000 gallons. The sectional area in a vertical plane is about 43½ sq. ft., the superficial area in plan is 42 sq. ft. A strong central shaft turns in bearings, and is driven by bevel gear, the arrangement being precisely like a brewer's mash tun. Wooden arms are attached to the shaft, and carry cross pieces. These are provided with a number of brass hooks, by means of which the hides are hung vertically, about an inch apart, all the metal work in contact with the liquor being brass or copper. Electrodes are placed against the sides of the vat. These consist of strips of copper arranged gridiron fashion. Four strips, 4ft. 3in. long by 2in. wide, are placed 8in. apart, and are connected at the top and at the bottom by strips of similar width. The whole surface exposed is, therefore, about 4 sq. ft. Experiments were also carried out in a rectangular vat, in which the hides were moved backwards and forwards longitudinally.

The tanning liquors were made of the usual materials, and during the tannage were strengthened from time to time in the usual way, and the hides were prepared for tanning by liming, unhairing, fleshing, and colouring, as practised by most tanners.

The current was varied in different experiments, according to the nature of the hides and strength of liquor. This is important in order to obtain satisfactory results. Previously to our investigation a series of experiments, in which the current varied from 1 to 30 amperes, was employed; best results were obtained with the weak currents, and the considerable loss due to electrolytic action when a greater current was employed was thereby avoided. With a current from 1½ to 4 amperes, the density is from ·375 to 1 ampere per sq. ft. of electrode, and from ·0345 ampere per sq. ft. transverse sectional area of the contents of the vat to ·092 ampere per sq. ft.

For currents from 1·3 up to 2·3 amperes, the total resistance of the liquor at 9°C., sp. gr. 1·01, expressed, for convenience, in ohms, was 8·7. On another occasion, at 7°C., sp. gr. 1·019, the resistance was 7·7 ohms, with 2·3 amperes. In each case the resistance was measured by observing the current and the volts between the electrodes. The quotient gives the sum of the ohmic resistance and of the polarisation. Exploration of the vat by means of a movable electrode showed that the flow of current was very uniform.

In our earlier experiments the current and voltage were observed, the vat being full of tanning liquor up to a certain mark. The hides were then put in, displacing a certain quantity of liquor. This was removed until it stood at the same mark as before, and the resistance was again determined. The results obtained in this way, however, did not give us any very definite information as to the variation in the resistance of the hides during their conversion into leather, but were sufficient to show that the hides when just immersed did not offer any material additional resistance to the electric current. Arrhenius (B. A. Electrolysis Report, 1887, 345) has previously pointed out that the resistance of solidified gelatin is not different from that of gelatin solution.

A more careful and accurate series of observations were subsequently made on the electrolytic resistance of the tanning solution, from which the following curves were obtained:—The temperature coefficient was, as might be expected, negative. The resistance decreased ·9 ohm for a rise of 1°C. or 1·32 per cent. at 16°C., falling from 75 ohms per cubic inch at 8·6°C. to 59 ohms per cubic inch at 26°C. The liquor was a strong solution containing 4·25 per cent. of tannin, obtained from mimosa bark and gambier, such as was employed during the later stages of the tannage. The same sample was tested for the purpose of ascertaining the true ohmic resistance and the fall of volts due to polarisation with different current densities on the electrodes. The resistance of the given sample of the liquor at 8·5°C. was 82 ohms per cubic inch—11 d where d is the density in amperes per square foot of electrode. This is shown by the straight falling line in Fig. 1—

$$v = 82 - 11\,d.$$

The voltage lost at the surface of the electrode is not so simple a quantity. It tends to a minimum of 1·4 volts for a minimum current, and the two following empirical formulæ closely approximate to the observed curve—

$$\text{Volts} = 1{\cdot}4 + 45\,d^{1{\cdot}2}$$

$$\text{or} = 1{\cdot}4 + {\cdot}194\,d + 8\,d^2$$

where d is the density of current in amperes per square foot. This is shown by the rising curve on Fig. 1.

A third series of tests were made to determine the change of resistance produced by diluting the liquor with water. The curve of the results of the observations, shown in Fig. 2 by the dotted curve, which evidently bears a strong resemblance to a rectangular hyperbola, and on analysing it by plotting the relation of the pro-

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duct of the resistance into the strength, with the strength (taking the normal strong liquor of 4·25 per cent. of tannin as 100) the result is a straight line, shown on the diagram, the slope of which is 63, and it cuts the axis of the abcissæ at 120. The curve is, therefore, a rectangular hyperbola, that is to say, the resistance is inversely proportional to the strength of the liquor, plus the resistance to which the curve is asymptotic, that is, the resistance of the saturated solution per cubic inch would be 63 ohms per cubic inch. The formula is, therefore, $r = \frac{120}{s} + 63$ where s is the strength of the liquor per cent., 100 being the normal solution referred to.

With the view of ascertaining whether the mechanical stirring of the liquor had any oxidising or other effect upon the liquor, a vat was filled and the frame was kept rotating as in ordinary work, but without any hides, for 24 hours. Analysis of the liquor before and after this treatment gave identical results as far as the practical

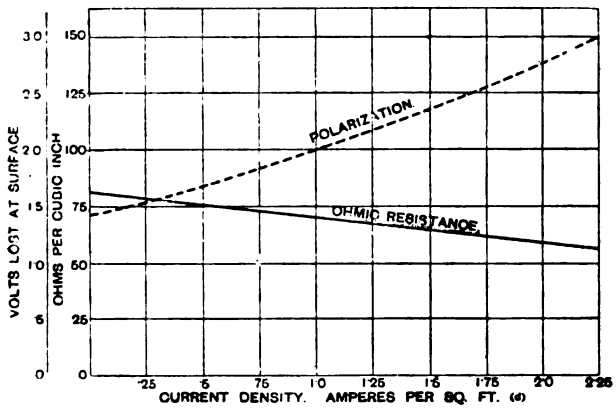

FIG. 1.—Polarisation Effect

point of the percentage of tannin is concerned, thus showing that the stirring has no effect other than that of continually bringing fresh liquor to act on the surface of the hides. A similar experiment was made to determine the effect of passing an electric current of ordinary working strength for 9 hours through the vat simultaneously with the motion of the frame. At the end of the experiment the liquor contained the same percentage of tannin. This result was to be expected, as the electrical power is remarkably small and the current density in the liquor is far below that of any ordinary electrolytic operation. Taking the mean volts and amperes of the second test already mentioned, and deducting 1·6 volts for polarisation, we have 36·8 watts expended in the liquor. It is obvious that this very small power, about $\frac{1}{20}$ of a horse power, can have but little effect on 2,000 gallons of liquor. The electrolytic effect is negligible when such weak currents are employed, since a

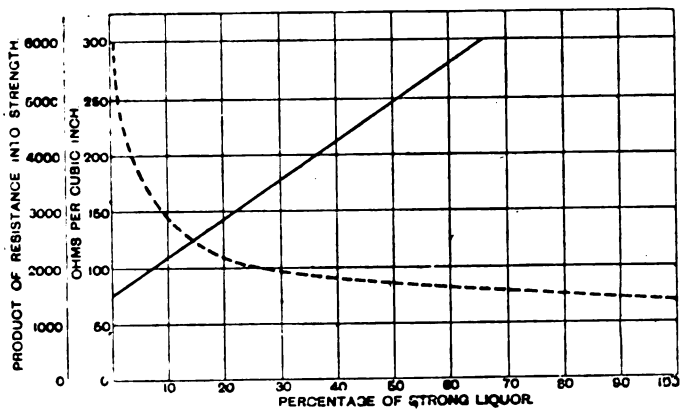

FIG. 2.—Variation of Resistance with Strength of Liquids.

current of 2 amperes will only liberate from water ·075 grm. of hydrogen and ·6 grm. of oxygen per hour, or during the whole process considerably less than 10 grms. of hydrogen would be evolved.

In our earlier chemical experiments with this process, our efforts were directed towards establishing the rate at which the tannin is taken up by the hides with and without the use of motion and an electric current. It was also of interest to determine whether the rate of tannage in the circular vats, in which the hides were suspended on a rotating frame, was similar to that obtained when a square vat was employed, and the hides suspended on a frame to which a reciprocating motion was imparted as already described. In these first experiments the rate of tannage was determined by noting the loss of tannin from the liquor after given intervals of time, and from the data so obtained calculating the average rate of loss per hour from the liquor.

The following table summarises the results obtained in three complete tannages, in which the process was discontinued at night, so that the electrical current and motion was only applied to the experimental vat for from six to eight hours per diem :—

Table I.

Experiment.	Loss of tannin per hour per 10,000 parts of liquor.	
	Day.— with motion and electricity.	Night.— without motion and electricity.
Circular vat 1, 1,600 gallons	·62	·344
Circular vat 2, 2,400 gallons	·612	·349
Reciprocating vat.....	·535	·338

The experiment in the circular vat 1 extended over a period of 26 days, during which time the machine was in motion for 167 hours, and a current of electricity applied for 98 hours to the 20 butts tanned in this experiment. The second experiment in vat 2 lasted for 33 days, during 209 hours of which the hides, 30 in number, were in motion, and a current of electricity passed for 115 hours. In the reciprocating vat 40 bellies and 20 shoulders were in the liquor for 27 days, the machine was in motion for 181 hours, and a current of electricity simultaneously applied for 82 hours. In each experiment the hides were completely tanned when they were taken out of the vat, and when finished were reported to be leather of excellent quality.

Daily temperature readings of the liquor were taken, but on no occasion was the temperature markedly different from that of the surrounding air, 15°C. being the highest reading recorded, and on some days the liquor being as low as 5°C.

The following table gives the actual experimental numbers obtained in the second of the above tannages, from which the average numbers given in Table I. for this experiment were obtained.

Table II.—*Circular Vat 2.*

A. With Electricity and Motion. Day.

Strength of liquor in parts per 10,000.		No. of Hours.	Total decrease per 10,000.	Decrease per Hour per 10,000.
Machine started.	Machine stopped			
92·8	89·4	5	3·4	·68
93·8	90·0	7	3·8	·54
84·6	81·2	5·5	3·4	·618
139·2	134·15	8	5·05	·63
127·8	123·05	8	4·75	·593

Average ·612 parts per hour per 10,000.

B. Night, at rest.

89·4	84·4	14	5·	·357
99·4	93·8	15	5·6	·373
90·0	84·6	14	5·4	·385
105·6	100·2	14	4·4	·38
133·8	129·6	14	4·2	·3
282·2	268·3	45	13·98	·304

Average ·349 parts per hour per 10,000.

The concordant nature of the above figures, as well as similar ones obtained in the other two experiments mentioned in Table I., at first led us to imagine that the hastening due to the combined action of motion and the electric current was expressed by these numbers. Further experiments, to be referred to later, however, proved to us that the rate of absorption at night, after the action of the electric current had been continued for some hours during the day, was much greater than that observed when the hides had not previously been subjected to this influence; in other words, the increased rate of absorption continued after the machine was stopped and the current was switched off. This effect may in all probability be attributed to the fact that as the hides pass through the liquor, the pores of the skins become distended and thus facilitate the passage of the liquor through the hides, which remain in this distended state for some time after they are brought to rest and the electric current cut off. When the machine is at work the hastening is further increased by the motion of the hides in the liquor augmenting the frequency of contact of tannin molecules with uncombed gelatin, and when the current is passing a further hastening is no doubt due to the increased motion of the tannin

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molecules through the liquor which such current imparts to them and its disposition on the suspended hide. An endeavour was also made to trace the change taking place in the hides during the absorption of the tannin, and from the series of numbers obtained it was noticed that the percentage of water present in the well-drained hide gradually diminished as the tannage became more complete, the fleshed hide containing approximately 77 per cent. of water and the leather as taken out from the vat from 45—55 per cent. according to the part of the skin examined. A gradual increase in the specific gravity of the dried skin was noticed, 1·062 being the lowest and 1·119 the highest specific gravity obtained. Samples of the leather obtained in these three experiments were subsequently tested by the Kjeldahl process and nitrogen contents ranging from 7·35 to 6·99 were obtained. Very little is apparently known as to the nitrogen contents of finished leathers, and although Böttinger (*Ann.* 244, 229) has shown that the compound of gelatin with oak bark tannin contains 9·4 per cent. nitrogen, and oak-bark tanned leather from 9·03—9·24 per cent., he has pointed out that both of these bodies are decomposed on heating with water, yielding a soluble compound of greater nitrogen content and an insoluble body containing only 7·79 per cent. nitrogen in the former case and 6·17 in the latter.

It is obvious that if the nitrogen content of a leather can be regarded as an indication of the completeness of the change, that simultaneous determinations of the actual quantity of tannin taken out of solution by an unknown weight of hide substance and their average nitrogen content, would give data which would be of value to the tanner, and enable him to predict the weight of his finished leather, and at the same time tell him the cost of the tanning material consumed in the work. Considerable difficulty was at first experienced in obtaining samples of the hide from time to time during the tannage that would represent the average composition of the leather. By taking the precaution, however, of taking the samples from a thick hide along the median line of the back from day to day, the error due to the varying thickness of different hides was reduced to a minimum, and the samples taken were then divided into two portions, one of which was dried at 100deg., rasped, and the filings analysed, whilst a second portion was frozen, reduced to fine shavings by means of a microtome, dried, and analysed, and thus gave a check on the former value. As these are probably the first experiments in which a thick sole leather has been produced in a time sufficiently short as to render it possible to trace the gradual diminution in the percentage of nitrogen in the hide with its absorption of tannin from the ooze, we give a table showing the results obtained in a recent experiment.

Thirty specially selected green hides were marked and weighed, limed in the usual way for six days, unhaired and fleshed, but not scudded, washed and coloured in a weak liquor for two days. Their total weight was 2,322lb., of which the horns, &c., weighed 104lb., giving a net weight of 2,218lb. used. The wet fleshed hides when introduced into the vat weighed 1,673lb., and after the tannage was completed on the twenty-second day, the wet leather taken out weighed 2,040lb. The leather has since been finished, and the weight in the dry and finished state was 986lb. The hair sold weighed 714lb. and the flesh 569lb. The following table gives the composition of the leather at different stages of the tannage and the amount of tannin disappearing from the solution.

Table III.

Date.	N. per cent.	Weight of tannin absorbed in lbs.
Fleshed hides :		
February 26th	16·5	...
February 28th	14·43	103·3
March 2nd	12·44	258·4
March 4th	10·56	400 3
March 9th	8·95	656·4
March 12th	...	760·0
March 20th	7·50	775·2

It will be noticed that the absorption after March 12th was very slow, and that the total gain in weight estimated from the tannin absorbed during the following eight days only amounted to 15lb., or about ½lb. per hide. This slight increase in the weight, unless it markedly affects the quality of the leather, cannot possibly compensate for the extra time and power spent after the fourteenth day. In this experiment the 775lb. of tannin consumed were obtained from mimosa bark and gambier, and for estimating the cost we may assume that 625lb. were obtained from the bark, and 150lb. from the latter. A 35 per cent. bark at £16. 10s. per ton would furnish 625lb. of tannin for £12. 9s., and a 50 per cent. gambier at £34 per ton would furnish 150lb. for £4·55, making a total cost for the tannin materials consumed in tannin the 30 hides, £17·45. Other materials would, of course, work out to a different cost, and if valonia or oak bark had been employed the cost of tannage would be considerably less.

It will be seen from the above figures that a very large amount of tannin was absorbed during the experiment which was not present in the finished leather obtained. We believe that this result is due to the large portion of the tannin consumed being deposited on the surface of the semi-permeable membrane, and subsequently being removed when the leather is washed and during the finishing process. The difference between the amount found in the finished leather and the amount lost by the liquor during the tannage can, of course, be utilised for further work. Ostwald (*Zeits. Phys. Chem.* 6, 71) and Tammann (*Zeits. Phys. Chem.* 6, 237) have recently drawn attention to the deposit of copper in this way from a copper solution on the surface of a semi-permeable membrane of copper ferro-cyanide, and it would seem probable that after the gelatin tannin compound is formed the deposition of tannin continues, but on the surface only of the leather. If the experiment had been stopped earlier, the quantity of tannin absorbed would have been less, and the amount removed from the surface in the finishing process also less.

Böttinger's experiments, already alluded to, point to a direct condensation of the gelatin and tannin taking place in the conversion of hide into leather, but so far as we are aware, there have hitherto been no direct experiments that this absorption took place gradually, and that there was a definite relation between the tannin lost by the liquid and the nitrogen content of the hide.

From analyses of the fleshed hide and finished leather, the decrease in the nitrogen value and increase in the oxygen per cent. has been repeatedly pointed out, but by those who held that no definite compound was produced, this change was attributed to the direct oxidation of the hide substance and loss of nitrogen as ammonia. The above experiments go far to establish that when tannin is employed the conversion of the hide into leather is due to a combination or condensation of the gelatin and tannin. We have not been able to ascertain what is the maximum amount of tannin which a given weight of hide will chemically absorb, but many of the samples of leather prepared by the ordinary process contain less tannin than the above. It is obvious that, provided the quality of the leather is equally good, the tanner, instead of aiming at the maximum yield of weight, should strive at the minimum yield, when tannin is worth more per pound than fleshed hide, and conversely when the economic conditions are reversed. The limits for a good leather appear to be approximately 40—60 per cent. hide substance, in union with 60—40 per cent. "tannin."

(To be continued.)

ON THE CHEMISTRY OF ACCUMULATORS.*

BY MATHIAS CANTOR.

The question as to the part played by hydrogen at the negative plate of a secondary cell is still unsettled. Although Gladstone and Tribe, as well as Frankland, found that lead or lead sponge cannot take up any appreciable quantity of hydrogen, Streinitz is of an exactly opposite opinion, and regards the amount of gas occluded as considerable, and its action as of great importance. Others, Drzewiecki and Schoop, for instance, conclude that a combination occurs between the lead and hydrogen. The author undertook a quantitative investigation into the various chemical processes occurring during charging and discharging, and he believes that by this means it is possible to arrive at a clear understanding of the matter.

Since the escaping gases, hydrogen and oxygen, can only be analysed quantitatively in the electrolyte, and not on the electrodes (without destroying them), an indirect method was adopted for the analysis of the latter. For one electrode a metal was used which undergoes no noticeable chemical change, so that any variation in the electrolyte depended only on the second electrode. As the positive electrode a plate of platinum was placed in a specially adapted glass vessel, the negative being formed of an E.P.S. plate, containing two or three sets of four meshes. The electrolyte used was a 28 per cent. solution of sulphuric acid. In the circuit, which was supplied by eight Meidinger cells, were also included a resistance box, a galvanometer, and a Hoffmann voltameter. Consequently, at corresponding electrodes in the voltameter and the secondary cell, equal volumes of oxygen and hydrogen were produced in the same time. Since the negative electrode consisted of a lead grid filled with lead oxide and lead sulphate, these three substances could enter into the chemical processes that occurred. At the low current strength employed (6 to 12 milliamperes) it was proved, from measurements of the volumes of the gases produced and analysis of the electrolyte, that the only change that took

* "Exner's Rep.," Vol. 27.

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place in the electrolyte was an alteration in its degree of concentration, which agrees with the results obtained by H. Aron and Frankland.

Before charging, the electrolyte contained hydrogen only in the form of water, whilst afterwards it existed partly as gas, partly as water, and, perhaps, also, in one form or the other, combined with the cathode. The total quantity of hydrogen must remain unaltered after charging, so that the amount of combined hydrogen at the cathode must be equal to the difference between the amount existing at first in the electrolyte as water and that existing in it in the same form after charging together with the quantity of gas produced. Experiments with several plates gave values for this difference, which were all found to lie below the probable error that might be expected, and they could therefore be neglected. It appears, therefore, that the negative plate cannot take up any appreciable quantity of hydrogen either by occlusion or in the form of a lead hydride.

From a comparison with the voltameter it was found that the whole of the hydrogen that might have been expected did not appear in the accumulator; the remainder in the "active" state was used in reducing lead oxide and lead sulphate, probably in the first instance the $PbSO_4$ to H_2SO_4 and Pb, since an increase in the amount of SO_3 in the solution was observed. The proportion between the "active" hydrogen and that that appears electrolytically, seems to bear some relation to the capacity of the plate. It does not, as Gladstone and Tribe conclude, increase as the current strength diminishes, but it is highly probable that for every plate a current density exists for which this proportion becomes a maximum.

Although Streinitz wishes to explain the evolution of gas at the cathode of a charged cell by the giving off of occluded hydrogen, and not through the decomposition of the sulphuric acid, it must be remembered that, on the one hand, J. Thomson asserts that lead at high temperatures decomposes water, and, on the other, that several metals, when in a finely divided and freshly reduced state, have properties which ordinarily belong to them only at high temperatures. The author describes experiments which demonstrate the possibility of such a decomposition of the water.

The result of his experiments on the chemical processes occurring at the negative plate during charging is as follows:—The lead oxide existing on the plate is transformed to the sulphate. The electrolytic hydrogen reduces the sulphate and forms sulphuric acid. The freshly reduced lead decomposes sulphuric acid again and liberates hydrogen, at the same time forming a sulphate again. The charging can be continued until a stationary position between the two reciprocal actions is reached.

UNDERGROUND TELEGRAPH WORK IN GERMANY.

A recent issue of *La Lumière Électrique* contains a brief account of the difficulties encountered in laying the Saxon section of the Munich-Dresden underground telegraph line.

To complete the network of subterranean telegraph lines in Germany it was decided last year to run a cable from Munich to Dresden, Munich being already connected in this manner with Stuttgart, and Stuttgart with Carlsruhe. The preliminary surveys having been made, work on the line began at the Dresden end on August 27, 1890. The cable employed contains seven ·7mm. copper conductors, each insulated with gutta-percha to a minimum diameter of 6mm. The conductors were further separated by thick layers of jute. The core had a total diameter of 23mm., and was sheathed with twenty 3·75mm. galvanised iron wires, wound spirally so as to make one complete turn per 32 or 35 cms. Over the iron armour was laid a coating of asphalt, then more jute yarn, and finally a second coating of asphalt. The cable was supplied in 1,000 metre lengths. All joints were enclosed in galvanised iron sleeves. Where passing through water and marshy land the cable was further protected from mechanical injury by a movable galvanised iron pipe composed of double sleeves 35cms. long.

The preliminary surveys led one to anticipate that the task of laying the cable would prove exceptionally laborious; but the reality exceeded all expectations. Hard rock, such as porphory, gneiss, diorite, quartz, and amphibole was met with. The pick made no impression on these rocks, and it was found necessary to blast for a distance of about 11½ kilometres, some five quintals (one ton) of dynamite being employed for this purpose.

Another circumstance retarded the progress of the work. Some eight more or less important towns had to be crossed, having extensive systems of gas, water, and sewer pipes. As the Imperial Telegraphs Department makes a point of having these cables as far as possible underneath all these pipes, it was out of the question in these towns to make use of the special laying waggon. It was, therefore, necessary to drag the cable through by hand, and 67 kilometres out of a total of 177½ kilometres were laid in this manner. The operation of dragging through occupied considerable time, especially in frequented places. Moreover, while it only required three workmen to *uncoil* the cable, at least fifty were required to drag it, a workman being stationed at every ten metres, and closer where there were curves. The work also necessitated the employment of men of endurance, the men having often to remain for hours together in water and in cramped positions. Poles, who are very suitable for this kind of labour, were employed.

The Bavarian frontier was reached on December 7th, and on April 6th work was commenced on the Munich portion.

THE DISTRIBUTION OF STEAM FROM THE CENTRAL STATION.*

BY F. H. PRENTISS.

The history of commercial electric lighting covers hardly a decade. The same is true of the sale of steam from underground pipes radiating from a central station. The pioneer work has been done, and the electric lighting companies are therefore in a position to reap the advantage of the experience gained, and to begin their work where the steam companies have left off. The joining of two enterprises together, such as electric lighting and the distribution of steam from central stations, has both its advantages and its defects. In a combined plant the general expenses of management, superintendence, and so forth, need not greatly exceed the cost for the same items in a single plant alone. An obvious disadvantage is the increased back pressure put upon the engines. The prejudicial effect of this back pressure is a subject which will well repay a little study. If this increase of back pressure is only that required for circulation of the steam for heating purposes, the increased consumption per useful horse power per hour will not be greatly augmented in consequence, provided the pipes are sufficiently large and properly run. The heating of residences by steam supplied from our Fifty-eight-street station is often effected with steam at a pressure of one or two pounds. And it is well known that there are several systems in use where exhaust steam is applied for heating in a manner so as to make it possible to produce a vacuum in the heating coils. In order to illustrate this point, I will present some calculations based upon a back pressure of 17lb. absolute, with an initial pressure of 92lb. absolute. We will call this case No. 1. For case No. 2 let us take the back pressure at 30lb. absolute and the initial pressure at 105lb. absolute. In case No. 3 let the back pressure be 105lb. absolute and initial pressure 180lb. absolute.

An engine working under conditions No. 3 would require 60lb. of water per H.P.H. In a similar manner, between the limits of pressure 90lb. (105lb. absolute) and 15lb. (30lb. absolute) there would be required 26lb. per I.H.P.H. This covers the case of an engine exhausting into low-pressure street mains. An engine exhausting into the atmosphere with 2lb. back pressure (17lb. absolute) and receiving steam at 77lb. (92lb. absolute), would require 19·7lb. of water per H.P.H. In actual practice the losses due to clearance, wire-drawing, incomplete expansion, cylinder condensation, &c., would have to be added to the amounts above given. For this we may add 10lb.

Take a concrete case. The engine was an automatic cut-off type, having been built for ordinary duty and not especially designed or altered for work of this unusual character. The engine was directly belted to a 750-light alternating current Westinghouse dynamo, which supplied current to about 600 incandescent lamps in the Lenox Lyceum. The building was wired throughout on the Edison three-wire plan, and the converters were arranged two in series, with a middle wire to suit these conditions. The plant was supplied with electric meters and the various station instruments, and represented, therefore, on a small scale, a central electric lighting station. The exhaust pipe of this engine was directly connected with our street mains, where an average steam pressure of about 55lb. was always maintained. The steam from the street mains was used in part for operating elevators in apartment houses and for running engines, and in part for heating. If we follow the steam in its course through the electric light engine, thence through the elevator, engines and pumps, and other engines along the line of the underground steam mains, and thence to the radiators where condensation takes place, it will be evident that an economy is attained similar to that in a compound condensing engine, the electric light engines playing the part of the high-pressure cylinder, the other engines playing the part of the low-pressure cylinder, and the radiators taking the place of the condenser. This engine was operated under these conditions three or four evenings a week for about a year, affording a perfectly steady and satisfactory light from the incandescent lamps. The running

* Abstract of a Paper read before the National Electric Light Association at Providence, R.I., February, 1891.

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of the engine was not attended with any special difficulties, and gave no more care and occasioned no more trouble than if exhausting into the atmosphere. On several occasions the exhaust of the engine was shut off from the street mains and turned into the atmosphere, the initial pressure being reduced at the same time to correspond. At other times the reverse of this change was effected and the exhaust turned from the atmosphere into the street mains without in either case producing a noteworthy fluctuation in the light from the incandescent lamps.

In order to make it clear beyond dispute that the business of a district steam company can be added to that of an electric lighting company without prejudice to the latter, two points only need be established: First, the possibility of utilising the exhaust of electric light engines without detriment to the light and without introducing any serious complications or expense in the management of the station; second, the certainty of an extra revenue, the net profits of which will equal or exceed the profits from the lighting plant for equal amounts of money invested.

I need, I think, only refer to the practical working of the combined system at the Fifty-eighth-street station of the New York Steam Company, where the back pressure of the engine was 55lb. (with no inconvenience and with no extra expense, save an almost indeterminate increased consumption of fuel) to prove that with a back pressure of only 15lb. a practical mechanical success is assured. Of course, to get the same power from the engines, it would be necessary, unless previously running with a light load, to increase the initial pressure 15lb., or to the same extent that the back pressure is increased. The effect of this, as I have shown, will be merely to pass a little more steam through the engine per horse-power, which ordinarily would be a bad practice and a waste of fuel, but when distributed and sold for heating purposes has nearly the value of live steam taken direct from the boiler. There would be times, of course, when the demand for heating would be slight, and when, therefore, it would be more economical to use a free exhaust, or, where there were several engines, to have only a portion of them deliver their exhaust into the street mains. The experiments of the New York Steam Company, previously cited, showed that the engines could easily be shifted from one exhaust pressure to the other without detriment to the light, and therefore be easily possible to secure at all times the maximum of economy which a combined system would permit. So far as profits and dividends are concerned a very considerable saving would follow by the mere union of the two interests, without even taking into account the value of the exhaust steam. Since, however, so much is dependent upon local conditions it is impossible to give figures which would apply to anything more than a hypothetical case. The amount of heat lost by radiation from the pipes of the New York Steam Company showed the loss to be about 3 per cent. of the carrying capacity of the pipes.

The average price received for steam from the aggregate of consumers, large and small, is somewhat more than double the cost of producing the steam at the boiler house. This average price is one willingly paid by the consumer, owing to the saving in cost of labour and to the many conveniences and advantages to be derived from having steam on tap, like gas and water. Since the cost of steam amounts to 50 per cent. of gross receipts, it is evident that if one-half of the steam sold for heating can be obtained from engine exhaust the saving effected in this way alone will amount to enough to pay a 10 per cent dividend.

In this Paper I have attempted to show the complete practical and commercial feasibility of combining a system of steam distribution from a central station with an electric light plant in a manner to utilise the exhaust.

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THE TELEPHONE.

The following letter appeared in *The Times* of yesterday:—

SIR: The Duke of Marlborough claims to have made a special study of the telephone for many years, and his letter shows that he understands the subject better than many who attempt to instruct the public regarding it. May I be allowed, in virtue of a similar claim, to say a word or two in reply?

The licences, as originally granted by the Post Office, were not "all-England" licences, inasmuch as the areas of operation were limited to towns. No inter-town trunk lines were permitted. Such lines could only be leased by the companies from the Post Office, and at exorbitant rates. So high were these rates that, although the companies were enterprising enough to comply in certain cases with the Post Office terms, the result in every case was heavy loss. After years of discussion the restriction was removed, but meanwhile the development of trunk-line communication—one of the most valuable of telephonic facilities—was practically blocked.

Nor were the only reservations those which the Duke of Marlborough mentioned. In addition (not to mention minor points), no company was to be allowed to run any line over any route which the Department might require in the future to use, no message was to be written down, no railway-line route over which the Department might have control was to be used, no post-office was to be connected up so that telegrams might be telephoned for transmission (even now this privilege is only accorded upon terms which are prohibitory), access to telegraph offices in order to establish call-offices for the public was denied, &c. In addition, a telephonic exchange service by the Post Office was announced, every post-office in the United Kingdom being placarded with notices that the Department was about to establish exchanges wherever required. In short, the licence was a maimed and distorted parody of what such a document should have been, and had (and has now even more strongly) all the appearance of a concession wrung from the Department in the fear that the verdict they had obtained might probably be reversed on appeal. The telephone interest in those days was too weak to carry the case higher, and accepted the inevitable with the best grace it could. It remains open to-day to any one to assert the principle that the Telegraph Acts never could have been intended to confer upon the Department an exclusive property in an invention totally novel in its principle and application, and not even dreamt of when the Acts were passed. The swaddling-clothes in which the business was enveloped by the Department, the apathy of the public, which for years all but ignored the utility of the invention, and the unredeemed promise of the Post Office to provide exchanges, all combined to render the earlier efforts of the companies costly and their progress slow.

To come, however, to the present state of the case, the Duke of Marlborough says that there is only a "small development" going on "in some of the large provincial towns of England," and that "practically no development of the telephone for social or business purposes exists." May I be allowed to say that this is an entirely erroneous view? In Scotland, for instance, which was the original field of the National Company's operations, every town of any importance is now in communication with all the rest. Recently, as an experiment, I myself, from Edinburgh as a centre, talked successively and successfully to every recognised business centre in Scotland, one after the other, without leaving my chair, and with only a few minutes' delay (at most) between each conversation. A similar development has gone on in the Midland counties of England and in the Western counties.

As regards the question of cost. When the National Company took over the business of the other companies, the average rate of subscription over its own system was under £12, and has since been reduced. The methods of the National Company have been now introduced over the whole of the area it absorbed, and the proof that these are appreciated is in the enormous increase in subscribers and revenue shown in its last balance-sheet, a rate of increase which, it is understood, is now being exceeded in the current year's operations.

The fact is that the whole telephone industry in this country has been prejudiced in the eyes of the public by the disgraceful mismanagement which prevailed in London until put an end to recently by the amalgamation of the companies. The effects of that muddling are still apparent. For two years the whole energies of the London staff have been devoted to rooting out the bad construction work of the United Telephone Company, and, as the Chairman of the National Company stated at the last meeting, another year must elapse before the work can be completed. Then, and only then, can the question of reduced rental be considered, because at the present moment I suppose no greater calamity could befall the Company than the accession of orders which a reduction of tariff would bring in. The work of coupling up could not, indeed, be overtaken.

A word as regards the single-wire system. It obtains simply because no other is possible. Powers to build subways do not exist, and if they did a reduction on the present tariff would be impossible at present owing to the cost of construction. Mr. Bennett's scheme is no doubt very ingenious, but the history of the Mutual Telephone Company, as illustrating the question of cost, does not lead us to suppose that his estimates under that head are not open to challenge. If the Duke of Marlborough will show how "it is demonstrable" that the whole of London can be telephoned on the twin-wire system with "a remunerative profit for a £10 a year subscription," I am certain the Directors of the National Telephone Company will be the first to thank him. Meanwhile, I think the best possible thing to be done will be to let the proposed new Company try it and give us the benefit of their experience.—I am, &c.,

F. FAITHFULL BEGG.

Bartholomew House, E.C., Aug. 31st.

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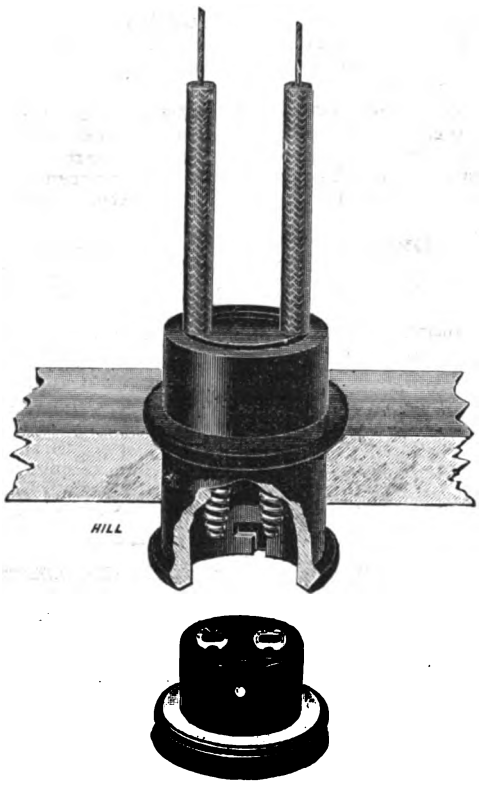
TRADE NOTES AND NOTICES.

NOW READY.—"THE ELECTRICIAN" PRIMERS (38 in all. Vol. I., 20; Vol. II., 18), in two volumes. Price per volume 2s. paper covers, 2s. 6d. cloth; post free, 2s. 2d. and 2s. 9d. respectively. Single copies, 3d.; post free, 3½d. Prospectus on application to the Publisher.

TENDER.—Tenders are invited, up to September 12th, for the supply of 40 tons of sulphate of copper to the Dirección General de Correos y Telégrafós, Madrid.

THE WEYMERSCH BATTERY.—On Friday last further demonstrations of the capabilities of this battery were given at the offices of the company owning the patent. The inventor, while not pretending in any way to rival the supply companies in point of cost, claims that the battery is especially suitable for isolated country residences. In order that there may be no bad contacts through bad electrical joints, mercury connections to some extent replace binding screws. It is claimed that the battery gives a fairly constant voltage for about 20 hours, at the end of which time the cells require to be re-charged with depolarising solution, which costs about a shilling per gallon.

NEW VITRITE CHEMICAL LAMPHOLDER.—Our illustration shows a lamp-holder which has been specially designed for use in chemical



works, starch factories, underground tunnels, and all places where sulphurous and other fumes are present. The Vitrite chemical holder entirely protects the metal lamp connections from any contact with the outer atmosphere. A special form of vitrite cap is supplied, which is sent to the lamp manufacturer, when ordering, for affixing to the lamp. A small rubber ring is placed on the cap, which enables the cap to be fitted to the holder, forming a perfectly air-tight joint. Connection is made with the spring in the body of the vitrite material itself, and enough length of insulated wire is provided with each holder to enable anyone to make a perfect insulated joint with the distributing leads of the installation, in the ordinary way. The spring connections in the interior are similar to those in use in the ordinary vitrite holder. A rim is placed near the top of the holder, so that the holder may be fitted into boards or other fixtures, if desired. Messrs. Woodhouse and Rawson United (Limited), of 88, Queen Victoria-street, E.C., are prepared to supply these holders.

CARBON WORKS FOR SALE.—Messrs. Wheatley Kirk, Price, and Goulty announce in our advertisement columns that they have for disposal by private treaty a small compact works, all the necessary plant and utensils, together with the stock of manufactured materials, office fittings, &c., as a current going concern.

ELECTRIC SHADES AND GLOBES.—We have received from Messrs. Woodall and Son, of Great Hampton-street, Birmingham, and 12, St. Andrew's-street, Holborn-circus, London, E.C., an artistic catalogue of designs in electric shades and globes. Some of these are very elegant, and should secure a large sale. The catalogue is well got up, and the more elegant designs are printed in colours. Messrs. Woodall and Son are manufacturers of all kinds of glass goods, and keep a large stock both in their London and Birmingham show rooms.

MESSRS. O. BEREND AND CO.—We have received from this firm a new price list of the electrical measuring and test instruments manufactured by Messrs. Hartmann and Braun, of Frankfort-on-the-Main, for whom Messrs. Berend and Co. are agents. The instruments comprise their well-known amperemeters, galvanometers, voltmeters, battery testers, resistance boxes, switches, pyrometers, &c. Messrs. Hartmann and Braun's instruments are all made on the interchangeable system by elaborate machine tools, each one being separately calibrated and run continuously for several weeks, and all calibration curves being preserved for reference.

GENERAL ELECTRIC COMPANY (LIMITED).—We have received from this Company an illustrated price list of their Manchester and Johnson microphones, either of which they are prepared to supply, completely fitted with battery bell or magneto-bell.

REMOVAL NOTICE.—We are requested to state that in future all communications hitherto sent to the Edison General Electric Company's address at Antwerp, Belgium, must be sent to the Edison General Electric Company, 34, Victoria Street, Westminster, S.W., where the principal offices of the European district of the American Company will be located. The warehouse at Antwerp, containing a complete stock of the Company's goods, will be continued as heretofore.

NEW FIRM.—Messrs. Mackenna, Macfarlane, and Co. inform us that they have commenced business as engineers and oil and general merchants, at 59, Southwark Bridge-road, London, S.E. Mr. Mackenna was for a considerable period with the late Mr. W. T. Henley.

DISSOLUTION OF PARTNERSHIP.—The firm of Mori and Co., carrying on business as electrical engineers at 3, Thornton's-buildings, Upperhead-row, and 40, New Briggate, Leeds, have dissolved partnership, as regards Mr. Frederick Mori. The business will be continued by Messrs. Edwin Moorhouse and R. P. Stocks.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

August 24, 1891.

14,238. J. FARQUHARSON. Acton. An improved method of insulating and laying electric light conductors under ground.

14,266. M. and A. E. HUMM. Forest Hill. Improvements in appliances for the administration of electricity to horses for curative purposes.

14,273. G. W. HART. Newark-on-Trent. Transmitting signals by means of an electric current, known as "Shadowgraph."

14,295. G. W. SPITTLE. London. Apparatus for protecting electric installations for telegraphic, telephonic, and lighting purposes from the effects of lightning or discharges of atmospheric electricity.

August 25, 1891.

14,322. W. W. SAVAGE. Brighton. Improvements in portable electric light holders. (W. W. Savage, Canada.)

14,379. N. M. GARLAND. London. Improvements in methods and apparatus for giving increased life and efficiency to arc light carbons.

14,386. G. C. DYMOND. Liverpool. Improvements in, or appertaining to, electric motors. (L. Gutmann, United States.)

14,388. G. C. DYMOND. Liverpool. Improvements in and relating to electric motors. (L. Gutmann, United States.)

14,390. S. Z. DE FERRANTI. London. Improvements in dynamo-electric machines.

14,391. A. SHEDLOCK. London. Improvements in couplings for insulated electrical conductors.

August 26, 1891.

14,397. J. S. PALMER and F. S. PALMER. London. Improved electric wire insulating composition.

14,409. G. BINSWANGER and H. J. COATES. London. Improvements in microphonic transmitters.

14,444. G. FORBES. London. Improvements in apparatus for the supply of motive power to electric generating stations and other works.

August 27, 1891.

14,462. E. SMITH. Halifax. Improvements in electrical appliances for automatically specifying any predetermined temperature.

14,508. J. S. WARBURTON. Grays, Essex. An improved arc lamp.

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14,509. B. J. B. MILLS. London. Improvements in electrical transmission of power. (H. W. Leonard, United States).

August 29, 1891.

14,585. R. H. NEWINGTON and E. PRIDDLE. London. The use of asbestos in the working of electrical fittings.

14,596. E. F. FURTADO and GRIST and TURNER. London. Improvements in telephonic switching apparatus.

SPECIFICATIONS PUBLISHED.

1890.

11,601. MATTHIESSON. Obtaining metals by electrical action. (Price 4d.)

11,962. LANCASTER. Electric bells. (Price 8d.)

12,439. SHEPARD. Electric lamps. (Price 11d.)

15,191. PAUTHONIER and L'INCANDESCENCE ELECTRIQUE SOCIETE. Incandescent electric lamps. (Price 4d.)

15,673. FRASER. Telephonic Switching and Signalling. (Price 1s. 1d.)

15,921. DICK and MACLEAN. Incandescent electric lamps. (Price 8d.)

1891.

6,846. LINVILLE. Printing telegraphs. (Price 1s. 7d.)

9,418. MACDONALD. Submarine batteries. (Price 11d.)

11,144. VAN HOEVENBERGH. Printing telegraphs. (Price 8d.)

11,519. LE SUEUR. Diaphragms for electric cells. (Price 4d.)

COMPANIES' MEETINGS & REPORTS.

Bath Electric Lighting and Engineering Company (Limited).

The statutory meeting of the shareholders of this Company was held on Saturday, at the offices, 2, Northumberland-buildings, Bath, under the presidency of Colonel Vaughton.

The CHAIRMAN explained, for the information of the shareholders, that the original Directorate of five had been increased to eight, one from the Brush Electrical Engineering Company, one from the Callendar's Company, and one a member of the firm of Messrs. Laing, Wharton, and Down, who were all large shareholders. The number of shares issued was 3,241, and their accounts had been thoroughly overhauled by Mr. Butcher, the accountant, so that they knew exactly what their position was. At present the light was only running a portion of the day and night, but it was hoped by-and-by to run it altogether; but that would depend on the number of customers. They were anxious to remove, as far as they could, every obstacle to the success of the undertaking, and so they would reduce the cost of installations to the lowest figure consistent, of course, with successful working, for all concerns must be worked at a profit. They would supply meters where required.

Mr. TITLEY, the solicitor to the Company, said the meeting was a formal one, it having to be held, under Section 49 of the Act of 1862, for the purpose of allowing the shareholders the opportunity of obtaining any information they might require, and also for declaring the number of shares taken up, which the Chairman had done. It was manifestly too early to give any account of the working of the concern, but it certainly could be said that the Company had started with exceedingly bright prospects. The present plant would permit of their working three or four times the amount of light now in hand, so that they could increase their revenue and profit without any very great additional outlay.

Major-General JERVOIS said that the Directors had given their attention to the popularising of the light, and the policy of the Company would be to make the installations as economic as possible. They had every reason to believe that the number of customers would increase, and that the advance would be sure, if slow.

A few questions having been put and answered, the proceedings terminated.

NEW COMPANIES, STATUTORY RETURNS, &c.

CALEDONIAN TELEPHONE COMPANY (LIMITED).—This Company, which was registered last week in Edinburgh, has been formed to acquire from Andrew Erskine Muirhead, Cart Forge, Glasgow, the business, stock, and plant carried on by him of supplying telephone communication; to establish a telephonic exchange or exchanges; and to carry on any business relating to telephones. The nominal capital is £50,000, in £1 shares. The first subscribers (one share each) are Walter Menzies, tube maker, Phœnix Tube Works, Glasgow; William Kenneth, shipowner, 13, George-square, Glasgow; R. Easton Aitken, C.A., 68, St. Vincent-street, Glasgow; Mark Hurll, coalmaster, 95, Bath-street, Glasgow; Robert M. S. Moore, C.E., 156, St. Vincent-street, Glasgow; James Wallace, dentist, 36, Dundas-street, Glasgow; A. Erskine Muirhead, Cart Forge, Glasgow; and William Barton, accountant, 109, St. Vincent-street, Glasgow.

G. FOWLES AND SONS (LIMITED).—This Company was registered on the 25th instant, with a capital of £5,000, in £5 shares, by E. C. Johnson, 412, Mansion House-chambers, E.C. Among its objects are the acquisition and carrying on of the business of G. Fowles and Sons, mechanical and electrical engineers, machinists, ironfounders, &c. Registered without Articles of Association.

HORTON AND SON (LIMITED).—This Company was registered on August 26, 1891, with a capital of £100,000, in £10 shares, by Jordan and Sons, 120, Chancery-lane, W.C. The objects are: To acquire and carry on the business of nut and bolt manufacturers hitherto carried on by Enoch Horton, under the name "Horton and Son," at Darlaston, Staffordshire. To carry on the business of mechanical and electrical engineers, toolmakers, metal workers, steel converters, &c. Enoch Horton, of Bescot, Walsall, is the first and only Director. Qualification of an ordinary Director (should any be appointed), 50 shares. Remuneration not specified. Office: New Alma Works, Station-street, Darlaston.

JOHN WARNER AND SONS (LIMITED).—This Company was registered on August 27, 1891, with a capital of £40,000, in £5 shares, by Messrs. Duffield and Bruty, solicitors, 6, Tokenhouse-yard, E.C. The objects are: To acquire and carry on the business of bell and brass founders, hydraulic, sanitary, mechanical, and electrical engineers, coppersmiths, braziers, &c, carried on by R. Warner, at Jewin-crescent, E.C. C. T. Richardson and A. Marriage are the first Managing Directors, and are entitled to £700 per annum and 10 per cent. of the amount available for dividend divided between them. Office: 27, Jewin-crescent, Cripplegate, E.C.

MEXICAN LANDS AND RAILWAY TRUST (LIMITED).—This Company was registered on August 25, 1891, with a capital of £100, in £1 shares (with power to increase), by Paine, Son, and Pollock, 14, St. Helen's-place E.C. It intends to acquire, take over, and work any concessions granted by the Government of Mexico, or of the United States of America, for the construction and working of any railways, telegraphs, telephones, waterworks, gas or electric lighting, and other public works. Registered without Articles of Association.

RAILWAY EQUIPMENTS SYNDICATE (LIMITED).—This Company was registered on August 31, 1891, with a capital of £10,000, in £100 shares, by the London Law and Trade Protection Association (Limited), 85, Gracechurch-street, E.C. The objects include the equipment of telegraph and telephone lines, electric works, &c. Registered without Special Articles.

W. F. MASON (LIMITED).—This Company was registered on August 29, 1891, with a capital of £30,000, in £10 shares, by C. Doubble, 14, Sergeant's-inn, Temple. The objects are: To acquire and carry on the business of an engineer (including civil, hydraulic, electrical, mechanical, sanitary, and otherwise) carried on by William F. Mason, at 504, Stockport-road, Longsight, Manchester.

WYLEYS (LIMITED).—This Company was registered on August 31, 1891, with a capital of £60,000, in £10 shares, by Waterlow and Sons (Limited), London-wall, E.C. The objects include the manufacture of, and dealing in, electrical, chemical, and scientific apparatus carried on by W. F. Wyley, at Wheatley-street, Coventry, and at 52, Moor-street, Birmingham, under the style of "Wyleys and Co." Mr. W. T. Wyley is the Chairman and Managing Director, and the office is in Wheatley-street, Coventry.

BOY MESSENGERS AND ELECTRIC CALL COMPANY (LIMITED).—By an agreement, dated May 7, 1891, between the Exchange Telegraph Company (Limited) and the above Company, the Exchange Company agree to sell and the Messenger to purchase certain electric call system instruments and apparatus, and, in full consideration therefor, 5,000 £1 shares, numbered 15,001 to 20,000 inclusive, will be allotted to the vendor Company or its nominees. An agreement of the same date between the Boy Messengers (Limited) and the above Company states that the former Company agree to sell all the lands, buildings, patents, telegraphs, and plant to the Messenger Company, and £25,000, of which £10,000 will be in cash and the remainder by the allotment of 15,000 £1 shares, will be considered full satisfaction therefor. A supplementary agreement of June 20, 1891, made between the same Companies, change the cash payment to £5,000, and 25,000 more shares will be allotted to the old Company. Office: Billiter House, Billiter-street, E.C.

COLLIER AUDIBLE TELEPHONE SYNDICATE (LIMITED).—An agreement, dated June 11, 1891, between the above Company of the first part, A. T. Collier (the vendor) of the second part, and the London and Colonial Finance Corporation, Limited (the promoter), of the third part, states that the Syndicate intend to allot 30 fully paid-up shares of £100 each, to A. T. Collier, numbered 28 to 57 inclusive, and 30 fully paid-up shares of £100 each to the London and Colonial Finance Corporation (Limited), numbered 58 to 87 inclusive. Office: 5A, Coleman-street, E.C.

INTERNATIONAL ELECTRIC SYNDICATE (LIMITED).—The office of this Company is situate at 59, Guardian-buildings, Manchester.

CITY NOTES, &c.

ALUMINIUM COMPANY (LIMITED).—At the fourth ordinary general meeting of this Company, held on Wednesday, the Chairman (Mr. G. W. Balfour, M.P.) stated that during the past twelve months the market price of aluminium had further declined in a very considerable measure, owing to the introduction of electrical processes for its manufacture, and at the present figure it was more beneficial to sell sodium direct than to employ it in the manufacture of aluminium. The Directors had accordingly turned their attention to the sodium branch of the Company's business,

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and their efforts in this line had met with a great deal of success. They hoped that the increased use of sodium, already resulting from experiments which had been made, would enable the Company to avoid liquidation.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the past week were £4,739.

CITY AND SOUTH LONDON RAILWAY COMPANY.—The traffic receipts of this Company for the week ended August 30, 1891, amounted to £717.

CUBA SUBMARINE TELEGRAPH COMPANY.—The estimated traffic receipts of this Company for the month of August were £3,000, as compared with £2,913 in the corresponding month of last year, showing an increase of £87.

DIRECT SPANISH TELEGRAPH COMPANY.—The Board of this Company have decided to recommend the payment of the dividend at the rate of 10 per cent. on the Preference shares, and a dividend of 5 per cent. (free of income-tax) upon the ordinary shares, for the half-year ended 30th June last.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this Company for the month of August, 1891, amounted to £53,393, and to £52,606 in the corresponding period of 1890, an increase of £787.

EASTERN EXTENSION TELEGRAPH COMPANY.—The receipts of this Company for August amounted to £53,398, as against £52,606 in the corresponding period of last year, showing an increase of £797.

ELECTRIC TRACTION COMPANY (LIMITED).—A meeting of the shareholders of this Company (in voluntary liquidation) will be held at the offices of the General Electric Power and Traction Company (Limited) 35, New Broad-street, E.C., on September 30th, at 11, for the purpose of receiving an account of the winding-up.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended August 28th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,215.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The receipts of this Company for the month of August show a decrease of £591 as compared with the corresponding period last year.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, August 26.	Price Wednesday, Sept. 2.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Sept. 2. Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
£1,300,980	Stock	12/0	Anglo-American	46½ 47½	47 48	5 14 7	Jan., Apr., July, Oct.	49	47⅜
£2,849,510	Stock	24/0	Do. Preferred	85½ 86½	86 87	6 4 1	" "	87⅜	86½
£2,849,510	Stock	5/0	Do. Deferred	11 11½	12¾ 13½	..	.. ..	14	11⅜
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99 102	99 102	3 18 5	January and July ..	..	..
130,000	£10	5/0	Brazilian Submarine	11¾ 12½	11¾ 12½	6 18 9	Mar., June, Oct., Dec.	..	..
£69,200	£100	5%	Do. 5 per Cent. Bonds	99 102	99 102	4 18 0	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107	103 107	4 13 6	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	107 109	107 109	6 8 10	April and October ..	108¾	..
16,000	10	8/0	Cuba Submarine	10 11	10 11	7 5 6	February and August	10 11/16	11⅛
6,000	10	10%	Do. Preference 10%	16½ 17½	16½ 17½	5 14 3	" "	16 1/16	..
12,931	5	3 3/32	Direct Spanish (£4 paid)	3¾ 4¼	3¾ 4¼	6 11 9	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9½ 10½	9½ 10½	4 15 3	" "	..	..
60,710	20	3/6	Direct United States	10¾ 11	11 11½	6 4 5	Jan., Apr., July, Oct.	11 1/16	10¾
400,000	10	5/6	Eastern	14½ 14¾	14⅝ 14¾	4 8 10	" "	14 1/16	14 3/16
70,000	10	6%	Do. 6 per Cent. Preference	15 15½	15 15½	3 17 5	" "	..	..
£1,200,000	Stock	6%	Do. 4 per Cent. Mort. Debenture Stock	107 110	107 110	3 12 9	May and November	..	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	107 110	4 10 11	February & August	..	..
250,000	10	2/6	Eastern Extension	14¾ 15	15 15¼	4 11 10	Jan., Apr., July, Oct.	15 3/16	15
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock	105 108	105 108	3 14 1	February & August	106½	..
£85,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	104 107	104 107	4 13 6	January and July ..	105½	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	102 105	102 105	4 15 3	" "	..	..
180,227	10	4/6	Globe Telegraph and Trust	9½ 9¾	9¾ 10	5 5 0	Jan., Apr., July, Oct.	10	9⅝
180,042	10	6%	Do. 6 per Cent. Preference	14¾ 15½	14¾ 15½	3 19 4	" "	15	14 13/16
150,000	10	5/0	Great Northern	18¾ 19¼	18¾ 19¼	4 8 4	Jan., April, and July	18¾	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883 xd	106 109	104 107	4 13 6	March & September	..	..
17,000	25	37/6	Indo-European	41 43	41 43	5 15 3	May and November	43	42⅝
38,348	10	5,0	London latino-Brazilian	6½ 7½	6½ 7½	6 0 0	" "	..	..
£100,000	100	6%	Do 6 per Cent. Debentures xd	107 110	104 107	5 12 2	March & September	..	..
9,000	8	4/0	Reuter's	8 8½	8 8½	4 14 1	April and October..	..	..
3,381	£100 Cert.	£1	Submarine Cables Trust 6%	117 121	117 121	4 19 2	" "	117	..
15,609	10	6/0	West African Telegraph	8 9	8 9	5 11 1	January and July ..	..	..
£281,400	100	5%	Do. 5 per Cent. Debentures xd	97 100	95 98	5 2 0	March & September	..	..
30,000	10	2/0	West Coast o America	2½ 3½	3¼ 3⅜	..	January and July ..	..	..
£150,000	100	8%	Do. Debentures 8% 1902	97 102	97 102	7 16 10	June and December	..	..
88,321	10	9d.	West India and Panama	1⅞ 2⅛	1⅞ 1⅞	..	..	1⅜	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	10 10½	10 10½	5 14 3	May and November	10½	10
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	9 10	8½ 9½	6 6 4	" "	..	..
61,683	15	9/0	Western and Brazilian	10¾ 11¼	10¾ 11¼	6 13 4	" "	11¼	10¾
30,364	7½	1/6	Do 5 per Cent. Cumulative Preferred	6½ 7	6½ 7	5 7 3	—	7	6½
30,364	7½	7/6	Do. 5 per Cent. Deferred	4¼ 4¾	4¼ 4¾	..	..	4⅝	4¼
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	102 105	102 105	5 14 3	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	102 105	102 105	5 14 3	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	117 122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, per Cent. Sterling Bonds xd	101 105	98 102	5 17 8	March & September	..	..
			TELEPHONES.						
224,850	14/0	0/5½	Consolidated Telephone Const. & Maintenance	⅜ ½	⅜ ½	..	May and November	½	..
220,000	£1	4·76d.	Oriental (11s. paid)	7/16 9/16	7/16 9/16	6 3 11	Yearly	..	..
438,984	5	3/6	National	4⅜ 4⅝	4⅜ 4⅝	6 3 1	June and December	4⅝	4 7/16
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½ 13½	12½ 13½	4 8 11	" "	13	12⅝
15,000	10	6%	Do 6 per Cent. Cumulative 2nd Pref. (£8 pd)	12½ 13	12½ 13	3 14 1	" "	12⅝	..
350,000	£10	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd)	105 107	105 107	4 4 1	..	106½	105⅞
58,000	5	1/0	United River Plate	1½ 2½	2 3	..	January and July ..	..	..
£146,370	tock	5%	Do. 5 per Cent. Debenture Stock	85 95	85 95	5 5 8	..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
1,000	£10	..	City of London Electric Lighting (£50 fully paid)	60 62	..	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	4½ 5	4½ 5	..	..	..	..
5,322	£5	..	House to House Electric	4½ 5	..	..	..	..	..
30,000	£5	..	Liverpool Electric Supply (£3 paid)	2⅝ 2⅞	..	..	..	..	..
111,000	5	..	London Electric Supply	2 2¼	1¾ 2	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	9¾ 10¼	9¾ 10¼	..	..	10½	10
7,730	£5	..	St. James' and Pall Mall	6¾ 7¼	6¾ 7¼	..	..	7⅜	6⅞
..	..	7%	Do. 7% Preference	4¼ 4¾	4¼ 4¾	..	..	..	..
42,853	5	..	Westminster Electric Supply (£5 paid)	5 5½	5¼ 5⅝	..	..	5¾	5⅝
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978		..	Brush Electrical Engineering	2⅝ 2⅝	2½ 2¾	..	..	2⅝	2½
69,996		6%	Do. 6 per Cent. Preference	1¾ 2	1⅞ 2⅛	5 12 11	June and December	1⅞	..
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	4 5	4½ 5½	6 7 3	January and July ..	..	..
17,139	5	..	Edison and Swan United	.. ..	.. ..	..	—	..	..
45,000	10	6%	Electric Construction	3½ 4½	3½ 4½	..	—	3⅝	3⅜
70,000	2	10/0	Elmore's Patent Copper Depositing	2⅜ 2⅝	3¾ 4	..	—	4	3⅝
20,000	5	..	Fowler-Waring Cables (£4 paid)	2 3	2 3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	19 20	19 20	5 0 0	February & August	19⅝	19½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	104 106	104 106	4 4 11	March & September	..	..
11,334	£10	6/1	International Okonite Limited Ordinary	7½ 8½	7½ 8½	11 15 3	..	..	..
11,334	£10	5/0	Do. Preference	9½ 9¾	9½ 9¾	8 4 1	..	..	..
78,949	5	2/1½	Swan United (£3. 10s. paid)	4½ 5	4½ 5	6 19 10	May and November	4⅝	..
37,350	12	12/0	Telegraph Construction and Maintenance	42 44	42 44	5 9 3	March and July.....	43½	43
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101 104	101 104	4 16 2	January and July ..	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£2. 10s. paid)	2½ 2⅝	..	..	..	..	..
—	£5	..	Do. Preference (fully paid)	3¼ 4	..	..	..	..	..
			RAILWAYS.						
50,000	£10	..	City and South London Railway	3 5	3 5	..	..	..	..

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

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NOTES.

The minutes of the proceedings of the Board of Trade Electrical Standards Committee contain a great deal of very interesting matter, interspersed with some dreary discussions of a more or less legal character. We alluded in our last issue to one or two points, and regret that it is impossible to make an intelligible abstract of the whole, owing to the proceedings being of a conversational order, and a large part of the work discussion of verbal amendments. The reasons for many of a these amendments, however, are of considerable interest; and the Blue Book, which is to be bought for elevenpence, should be in the hands of all those who are interested in this important matter. Among the unexpected difficulties was one which, while it concerns almost every trader in the country, is probably known to only a few. The yard is the one standard of length which is paramount over all multiples and fractions of it. The chain, the foot, the inch, and many multiples of these, have been separately named as legal denominations by an Order in Council; and it is illegal to use a 37-inch rod for measuring calico, and the "blue" used for measuring beer at Cardiff, three "blues" going to a pint, is an illegal measure. Sir William Thomson pointed out that 10,000 million "denominations" of the ohm, at least, would be required if this precedent were followed.

In commenting upon the Report, our contemporary *Nature* objects to the use of the word "pressure" in connection with the volt, as it "has certainly led to very erroneous notions in the minds of the general public as to the functions of electric supply mains," and advocates "voltage." The Board of Trade had sanctioned this word before the Electrical Standards Committee was appointed, and the Committee have apparently accepted it without objection. The great thing is to avoid the term "electromotive force," and while "the volts" and "voltage" will generally suffice, some other word is often required. Why is "pressure" more erroneous than "current"? Does anything flow? The word "electricity" has very properly been dropped. We do not know that it flows or even exists; we find that it is easy to get on without it. Any ideas which the public may have are pretty much the same as they were before the Board of Trade used the word "pressure." The expression is not, as our contemporary says, more misleading than "tension," because there was a distinctly erroneous idea a few years ago of quantity currents and high-tension currents as indicating two different kinds or qualities of something that was called electricity. Electromotive force is doubly wrong, as well as pedantic, but "pressure" is a word borrowed, as is "current," from our everyday language; they do not attempt to be explanatory, and are undoubtedly of a temporary character.

The Electrical Standards Committee of the British Association have a printed form bearing the address, "Cavendish Laboratory, Cambridge," being a certificate of comparison of resistance coils sent by makers or others, with the B.A. units, which are kept there. This form states that "It has been assumed, for the purposes of comparison, that one legal ohm is equal to 1·0112 B.A. units." The word "legal," which was never justified, is erased on one of these certificates, which is now before us, and the 1·0112 is altered to 1·01358.

Now the report, after defining "the ohm," which will shortly rank with the yard and the pound, and which may, therefore, be called the Imperial Ohm, alludes to the B.A. unit as being ·9866 of the ohm; that is, the ohm is 1·01358 B.A. units. Now, the "legal" ohm referred to on the certificate was the 106 centimetre compromise, which was agreed to at Paris in 1884, but which has produced nothing but confusion, and, fortunately, has been accepted by very few electricians. But the ratio of 1·0112 to 1·01358 is not the same as 106 to 106·3, but as 106 to 106·24948, say 106·25. The certificate in question was given to Messrs. Nalder Bros., for a resistance coil which has been found to be 1·00005 ohms at 16·8°C. The following table gives the relations of the various ohms:—

	In terms of mercury standard.	In terms of B.A. unit.
B.A. unit	104·8	1
Paris Congress, 1884, or so-called legal ohm	106	1·0112
"True ohm" so called (Jamieson)	106·2	1·0131
Imperial ohm (Board of Trade)...	106·3	1·01358 (?)

The problem of preventing a spark on rupturing or cutting an electrical conductor in a coal mine is not an easy one, and the ingenious cable which is described elsewhere seems to solve it in a satisfactory manner. This invention was made, and a cable manufacturer had with difficulty been induced to carry it out, before the reading of the important Paper on Electrical Mining Machinery at the Institution of Civil Engineers, but owing to the incomplete state of the patent the authors were compelled to be silent about it, much as a

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description of it would have enhanced the interest of their communication. While it will naturally be accepted with great caution, the cable can undoubtedly be tested as to its non-sparking properties with much greater ease than a coal-cutting motor; for, as in experiments which have been carried out with it, a considerable self-induction can be introduced to exaggerate the spark by putting the magnets of a dynamo in series with it, and cutting or rupturing it in the dark. We understand that, after careful and satisfactory tests, some four miles of this cable have been ordered for Lord DURHAM'S coal mines.

THE safety cable depends for its effectual action on the working of fuses and automatic cut-outs, and it is obvious that these must be arranged for the rapid interruption of the circuit. The cable was exhibited at Prof. S. P. THOMPSON'S British Association lecture on Electricity in Mining, and was arranged for showing the action of the fuse and knock-over switch on rupturing the cable. But the second device, a resistance for guarding against crushing or cutting, and consequent contact between the outer and inner conductors, was omitted; and, by one of those luckless mishaps which are apt to occur in lecture experiments, this very contact was made, and the result caused an unfavourable impression on the audience, an impression which we hope this explanation, and a perusal of the description of the cable, will remove.

THE above information, by-the-bye, we received yesterday by telephone from Harrow-road, a sufficient proof of the great improvement which has been effected of late in the service. Two or three years ago communication with the outlying parts of London was almost useless, speech being very feeble and smothered with cross-talk and other disturbances, and conversation being generally restricted to shouting, "Are you there?" and "Who are you?" while the lady at the exchange would occasionally encourage the subscribers by suggesting that they should "Speak up!"

WE commence in the present number a series of articles by Mr. G. F. C. SEARLE, of Cambridge, on "The Determination of Currents in Absolute Electro-Magnetic Measure." Our object was, in the first place, to present to our readers a description of the work of Lord RAYLEIGH in his determination of the ampere, now that this is about to define one of our two primary electrical standards. The author has, however, written a considerable amount of introductory matter dealing with those dynamic properties of the current which are utilised in making the measurements, and this will not only form an introduction to the description of Lord RAYLEIGH'S research, but will be a *résumé* of the electro-magnetic system of units and the method of applying it to practice.

Electrical Engineering Exhibition.—It is proposed to hold an Electrical Engineering Exhibition at Glasgow this winter.

Alicante.—Messrs. Siemens and Halske are equipping a central station at Alicante, in Spain. Power is to be derived from gasmotors.

The Berlin-Munich Subterranean Telegraph Line.—This line, to which we referred in our last issue, is now completed, and is expected to be at work in a few days, as soon as the necessary tests have been carried out.

Sheffield.—The Town Council have decided to apply for an electric lighting order, unless satisfactory arrangements can be made with a company.

Nomeny.—The town of Nomeny (Meurthe-et-Moselle) will shortly possess an electric light station, in which the necessary power is obtained from the adjacent river.

Budapest.—The lighting of the palace at Budapest has been entrusted to Messrs. Ganz and Co. The installation will include 8 arc lamps and about 2,700 incandescents.

Glasgow and West of England Technical College.—The 1891-2 session of this College commences on Monday, October 5. Further particulars will be found in our advertisement columns.

New Cable.—The new submarine cable, establishing direct communication between Brazil and the United States, was opened for traffic last week. This cable belongs to the Société Française des Télégraphes Sous-Marins.

Electric Traction in Russia.—According to the *Elektrotecnischer Anzeiger* it is expected that the Allgemeine Elektricitäts Gesellschaft will equip a tramway line in Kiew with their overhead wire system of electric traction.

The Chicago Exhibition.—Sir Henry Trueman Wood and Mr. James Dredge started on Saturday for Chicago, as representatives of the Royal Commission for the Chicago Exhibition, and with the object of making preliminary arrangements for the British Section there in 1893.

Electricity in Mines.—At the recent annual meeting of the National Association of Colliery Managers, at Newcastle, the President advised colliery managers to begin to accustom themselves to electricity, and to make themselves familiar with the rules relating to its measurement.

The Lauffen-Frankfort Transmission Plant.—Our Frankfort correspondent informs us that the current from Lauffen at 15,000 volts has during the past week been used daily, after transformation, for lamp lighting with complete success. The motor on Wednesday was running at full load, driving the pump for the artificial fountain.

Electric Inspector.—The City of Liverpool (City Engineer's Department), as will be seen by our advertisement columns, wants a well-trained electrical engineer to act as electric inspector. The person appointed will not be allowed to engage in private practice, and will be required to devote his whole time to the duties of his office.

Electric Lighting at Damascus.—The *Levant Herald* says that among the applications for concessions for public works now being considered by the Minister of Public Works, is one for the lighting of Damascus by electricity. An application for the building of an electric tramway in the port of Smyrna is also at present under consideration.

The Telephone in East Prussia.—Telephone lines connecting Berlin, Posen, Bromberg and Königsberg (400 miles), and Berlin, Schneidemühl, Dirschau, Danzig, Elbing and Königsberg (350 miles) are projected. Both lines will pass through Landsberg. The Landsberg—Frankfurt-on-Oder—Berlin line (100 miles) is to be opened on October 1st.

The Telephone in Kent.—Since the amalgamation of the South of England Company with the National Company, th telephone system has made great progress in Kent. A trunk line is being worked down from London, and will cross the Thames at Gravesend, and from thence will be carried from Chatham to Maidstone, whilst a branch line is being constructed to Minster.

Thunderstorms.—There has been the usual quota of thunderstorms during the past 10 days. On Saturday, the 29th ult. a severe thunderstorm broke over Willingham, in Hampshire. The lightning struck a wheat-cutting machine, shattering one of the rakes, throwing the driver and killing the two horses. In the North and along the East coast houses have been struck and cattle killed.

Physical Research Studentship.—An election to the Coutts Trotter studentship at Trinity College, Cambridge, will take place next month. Applications from candidates must be sent into the College office, addressed to the Secretary of the Coutts Trotter Studentship Committee, on or before October 15th.

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The studentship is tenable for two years, and is for original research in physiology or in physics.

Brighton.—At the meeting of this Committee, held on August 24th, Mr. Shoolbred reported that he had received a communication from Messrs. Sharp and Kent, stating that they were willing to carry out the work of wiring and fitting up lamps at the generating station, for the amount mentioned in their estimate of July 30th last, viz., £189. 15s. The Committee resolved that the firm named carry out the work.

The Electrical Utilisation of Water Power.—At a recent meeting of the Société des Ingénieurs Civils reference, says *La Lumière Electrique*, was made to a hydro-electric plant now being erected at Saint-Michel for M. Adolphe Minet. Power is obtained from the falls of the Valloirette. The ultimate available power amounts to 30,000 H.P.; though some 6,000 H.P. only will at present be utilised. The works will be devoted to various electro-metallurgical purposes.

The British Association.—The meeting of the British Association stands adjourned until Wednesday, August 3rd, 1892, at Edinburgh, when the president will be Sir Archibald Geikie. In 1893 the British Association will meet in Nottingham. The following are some of the money grants made: Prof. Carey Foster, "Electrical Standards" (partly renewed), £27. 4s. 6d.; Prof. G. F. Fitzgerald, "Electrolysis," £5; Dr. Lodge, "Discharge of Electricity from Points," £50.

City and Guilds of London Institute.—The matriculation or entrance examination for the Central Institution will be held on September 21-24th; and for the Day Department of the Technical College, Finsbury, on September 29th. The new session of the Central Institution commences on September 30th. The next session of the Finsbury Technical College commences on October 6th. Further particulars will be found in our advertisement columns.

Crystal Palace Electrical Exhibition, 1892.—The Special Committee appointed by the Electrical Section of the London Chamber of Commerce to co-operate with the Directors of the Crystal Palace Company in promoting the success of the Exhibition, consists of the following gentlemen: Mr. R. E. Crompton, (Chairman), Major S. Flood Page and Mr. Emile Garcke (Vice-Chairmen), Mr. J. E. H. Gordon, Mr. G. Binswanger, and Mr. Alexander Siemens.

Canterbury.—At a recent meeting of the Town Council a letter from the Brush Company was read, in which they stated that they were willing to undertake the formation of a company to take over the Provisional Order and to pay the expenses of it, depositing 10 per cent. as security. Several members were of opinion that it would be better to refer the matter to a small committee to make terms with the Company and place them before the Board of Trade. This was agreed to.

Portsmouth.—At the last meeting of the Town Council it was finally resolved to adopt the electric lighting scheme, which will, it is estimated, involve an outlay of £60,000. At one time it was thought that the introduction of electric lighting into Portsmouth would be left to private enterprise. A company was formed, but the Town Council afterwards determined to apply for an order, and the company was dissolved. Mr. Shoolbred was consulted by the Town Council, and he recommended the adoption of the low-pressure system, supplemented by storage batteries, distribution to take place on the three-wire system. The capacity of the station will be at first 10,000 8 c.p. lights.

Glasgow.—At a recent meeting of the Town Council, the sub-committee of the Tramways Committee reported that they were of opinion that it was desirable, after the termination of the present lease (1894), that the working of the Glasgow tramways by means of horses should be discontinued as far as possible, and that mechanical traction, by means of electricity, cable, or compressed air, should be substituted. Before, however, coming to any conclusion as to the respective merits of these several systems with reference to Glasgow, the sub-committee recommended that the fullest information should be got as to their relative cost and advantages; and that it should be remitted to the sub-committee to obtain this information. The report was adopted.

The Telegraph in Norway.—The following table will give an idea of the deviations necessitated by the nature of the country in Norway when running telegraph lines:—

Places connected.	Distance as the crow flies, in kilometres.	Length of the telegraph line.
Tromsoe—Alten	170	330
Alten—Kistrand	90	150
Kistrand—Hammerfest	60	70
Kistrand—Gjesvaer	70	150
Tromsoe—Hammerfest	210	550
Hammerfest—Gjesvaer	80	170
Tromsoe—Gjesvaer	300	580

Birmingham Municipal Technical School.—The School has been established for the purpose of carrying out a liberal scheme of technical education, which has been rendered possible by the Technical Education Act of 1890. The Committee earnestly desire that the instruction given may be of practical value to all sections of the community, and have, therefore, endeavoured to provide, on broad lines, classes which shall be of service for all the local trades. As regards payment, it is the wish of the City Council that the amount of the fees should be so low as not to prevent the poorest from entering the school. Chemical, Physical, Metallurgical, Electro-Metallurgical Laboratories, and a well-equipped Machine Shop have been provided. The first session begins next Monday, and ends on Saturday, April 30, 1892. A number of scholarships admitting to the classes in each of the trade groups will be awarded on the result of the examinations to be held shortly.

The Practical Efficiency of Telegraphic Apparatus.—The following table relating to the "efficiency" of the various telegraph instruments employed by the French Post Office may be of interest. The figures are taken from an article in *La Lumière Electrique*. A message is reckoned at 20 words, and each word at 7·5 letters:—

Apparatus.	Average number of messages per hour.	Number of operators.	Average number of messages per hour per operator.
Morse	25	2	12·5
,, (duplex)	50	4	12·5
Sounder	40	2	20
,, (duplex)	80	4	20
,, (quadruplex)	160	8	20
Wheatstone	100	10	10
,, (duplex)	200	18	11
Delany (quadruplex)	160	8	20
Baudot (quadruplex)	160	10	16
Hughes	50	4	12·5

The Production of Ozokerite in the United States.—Ozokerite, or "mineral wax," belongs to the series of hydrocarbon compounds, which include marsh gas, petroleum, and paraffin, it being very similar in appearance to the latter. It is colourless to white when pure, but frequently occurs leek-green, yellow and brown. Prior to 1888 the only locality producing this mineral oil was the province of Galicia, in Austria. Mining began there in 1862, and though at first it was found exceedingly difficult to obtain sufficient capital to push the enterprise, it has increased rapidly since that date, and at present there are 35 companies engaged in the industry in the province of Galicia alone. For 26 years production was limited to this locality, but in 1888 American ozokerite began to receive the attention of the trade, and considerable work was begun upon a newly discovered vein in Utah. The mineral had been known to exist in Utah for some years, but whether in paying quantity was not satisfactorily determined until August, 1888. The production of 1888 was estimated at 65,000lb. of crude mineral. The production for 1890 probably exceeded 300,000lb. Refined ozokerite is used for nearly all the purposes to which ordinary bees'-wax is applicable. Crude ozokerite, like other hydrocarbon compounds, is used to a considerable extent as an electrical insulator.

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Phosphorescence.—M. Henri Becquerel has recently studied the different manifestations of the phosphorescence of minerals under the influence of light and heat, and has communicated some observations upon the subject to the Académie des Sciences. The result of M. Becquerel's experiments up to the present time is to place the phenomenon of phosphorescence induced by heat (hitherto considered as distinct from all other phenomena of the kind) once more into the class of known and studied phosphorescence effects. One fact in particular deserves attention in connection with this subject—the conservation to an indefinite time in certain bodies of a portion of the energy which they have absorbed, and which they emit upon being heated. M. Becquerel asks by what mechanism this energy is thus maintained in its potentiality without appreciable loss. He declares himself unable for the present to answer this question; but he looks to future research for information upon the subject, which may have the most important bearing upon the state of knowledge of the mechanism of light radiation and the storing of energy in its highest and most intense forms.

Electric Lighting Statistics of the American Census.—In a recent issue the *Electrical Engineer* of New York devotes a leading article to some electrical statistic spinning from the census return on the "Social Statistics of Cities." It seems that 309 American cities, with a population of 16,335,659, have for their streets 182,671 gas lamps, 53,696 electric, and 57,480 oil. Each of the 293,847 lights costs $35.50 per annum. Gas is now used exclusively for street lighting in only 13 cities, whereas electricity is exclusively used in no fewer than 125. Another table of interest is that containing the condensed figures of cities up to 100,000 inhabitants. In 278 of these, with a population of 7,018,653, there are 35,191 electric lights, compared with 35,127 gas. The value of electric lights is brought out by the table which furnishes details as to the number of lamps to the mile of street. Thus in New York, where there are only 1,369 electric lights to 25,483 gas lamps, there are 46·92 lamps to each mile. In Buffalo, where there are 1,223 electric lights to 4,377 gas, there are only 15·05 to each mile. Denver, with 1,750 electric lights and no other lights, has only 2·31 to the mile.

Exports of Telegraphic Apparatus.—The August trade returns, so far as they refer to the exports of telegraphic wires and apparatus connected therewith, are again most satisfactory; in fact, the value of the exports last month was phenomenally large, having amounted to more than twice as much as in the corresponding month of either last year or the previous year. Our exports under this head, previously this year, have been very heavy, and the increase in August has brought up the total exports for the first eight months of this year to approximately 1¼ million sterling. In the following table we show the value of the exports for August, and for the eight months, in comparison with the corresponding figures of the two previous years:—

	1891.	1890.	1889.
First quarter...	£653,081	£324,670	£431,309
Second quarter.	331,449	397,042	145,147
Six months.....	984,530	721,712	576,456
July.....	150,754	56,575	32,909
August	112,690	55,601	45,452
Eight months...	£1,247,974	£833,888	£655,817

Standards of Electromotive Force.—The following suggestion emanates from our New York contemporary, the *Electrical World*:—"It is rather odd that electromotive force should be so unreasonably difficult to determine. No aspersions are to be cast on the Clark cell, but it is only adapted for open circuit, and has a trick of getting out of order on very small provocation. The thermopile has been from time to time proposed for the purpose of a standard, but the electromotive force of a single element is exceedingly small, and, furthermore, the working of the apparatus is anything but constant. In this exigency why would it not be well to turn to the dynamo, not as a source of electromotive force of the utmost scientific accuracy, but as one capable of giving very conveniently such a range of electromotive force as is desirable in applied work, and of being operated on closed circuit within reasonable limits and without perceptibly impairing its exactness? Of course a dynamo for such a purpose would have to be specially constructed. It would probably be best to use a comparatively small quantity of iron, of the very highest magnetic properties, as carefully annealed as the core of a transformer—the windings would be arranged with special reference to keeping their temperature steady, and the armature would have to be constructed with the same object in view. Such a machine, when run at a constant known speed, would give an electromotive force definite enough and constant enough for all practical purposes, and would furthermore possess the great advantage of giving a very perceptible current without changing the electromotive force, particularly if, as might readily be done, compound winding were applied. Changing the speed would give a beautifully easy way of obtaining any desired electromotive force. The motive power would naturally be an electromotor directly coupled to the shaft and furnished with a shunt box, for the purpose of enabling its speed to be adjusted to exactly the proper point. The cost of such apparatus would be but little more than that of a battery of standard cells, such as is required in any laboratory of considerable size, and its use would probably be found in the long run to be for all ordinary circumstances much more convenient and reliable. Considerable care would be necessary in constructing such a standard dynamo, both to insure freedom from errors through heating and the requisite constancy of the magnetic qualities, but the advantages of the plan are sufficiently numerous to warrant trying it in spite of these minor objections."

Manchester Technical School.—A new department of physics and electrical engineering will be commenced this session at the new branch of this school in Whitworth-street, where a large well-lighted warehouse is being fitted as follows:—Basement: Dynamo house, with 14 H.P. Crossley engine. Dynamos and motors, arranged specially for purposes of instruction. Secondary battery room, with a set of 27 high-discharge accumulators, arranged with switchboard for illustrating the application to instrument calibration and to electric light installations. Complete appliances for electro-chemical operations. General workshop conveniences for electrical instrument making, including electrician's power lathe. Ground floor: Electro-technical museum and advanced physical laboratory. In the former will be arranged samples of manufactures presented or lent by different electrical firms. In the latter, electrical testing instruments of the most approved construction will be provided. Also a library of works relating to general physics and electrical technology. First floor: Lecture room. Second floor: Elementary physical laboratory. The building will be lighted by electricity, the installation being fitted up with especial regard to purposes of instruction. The regular scheme of study extends over two years, though students may remain for a longer period, and is designed to give a satisfactory training in pure and applied physics, pure and applied mathematics, geometrical, freehand, and mechanical drawing, applied mechanics, steam and the steam engine, machine design, theoretical and practical chemistry, and metallurgy (the latter for second year students), and in the German language. Systematic practice is provided in the school workshops in the use of wood and metal working tools, both hand and power. The workshop course is arranged so as to give sufficient instruction in wood, brass, iron, and sheet metal-working to enable students to construct efficient electrical instruments. The mechanical drawing, especially during the second year, will have reference more especially to the design and arrangement of electrical plant. In the evening department, in addition to the usual courses of general physics, special instruction will be provided in electric lighting and power transmission, as well as telegraphy and telephony, the two latter subjects being under the charge of Mr. Taylor, of the Manchester Postal Telegraphs. After Christmas a course of six lectures on electric bells, designed chiefly for plumbers, will be given, and during the summer term lectures and laboratory work, devoted to the study of electro metallurgy and alternate currents of electricity, have been arranged.

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MAGNETISM IN IRON AND OTHER METALS.*—XLIX.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 496.*)

§ 176. **The Constraint of the Molecules due to their Mutual Action as Magnets.**—The matter becomes immensely simplified if we put aside all these arbitrary postulates regarding directive force and resistance to turning, and inquire what is the character of the constraint the molecules necessarily suffer through the forces which they exert on one another in consequence of the fact that they are magnets. It appears that this constraint is sufficient to account for the observed characteristics of the process of magnetisation, that it completely explains hysteresis, and that it at least offers a clue to those complicated variations of magnetic quality which are known to be caused by the variation of such physical conditions as temperature or stress.†

In proceeding to consider the equilibrium of the molecules under their mutual magnetic forces, it is clear that we cannot confine our attention to any one molecule. For the directive force that acts on any one molecule depends on the positions of the molecules which surround it, and becomes altered when these are disturbed. We cannot investigate the equilibrium of the individual without including in the question the equilibrium of its neighbours. When an external force is applied, they, as well as it, are deflected, and the constraint they exercise on it suffers change. What must be studied is the configuration of the group as a whole, and the manner in which the group becomes distorted, broken up, and rearranged in the process of applying and removing an external magnetising force.

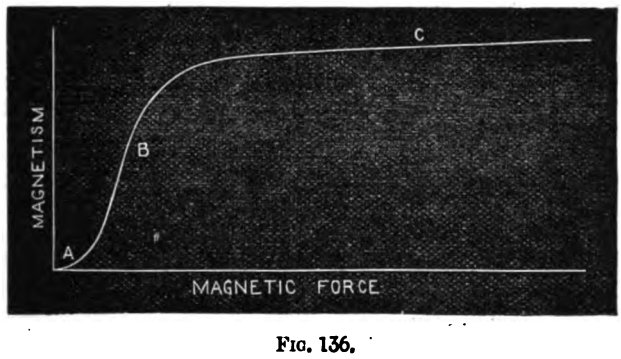

Fig. 136.

In seeking to find in the mutual constraint excited by the magnetic molecules, an explanation of the changes of susceptibility which are observed as a magnetising force as gradually applied to a piece of iron or other magnetic metal, it should be borne in mind that the magnetising process may be broadly divided into three stages (as was remarked in § 141), namely, the stages A, B, and C of the typical curve (Fig. 136).

They admit, in general, of being distinguished from one another without difficulty, though the passage from one stage to the next is never perfectly abrupt. In some cases, however, it is remarkably sharp, as in the curves of Figs. 120 and 121, which relate to nickel under torsion, and under a combination of torsion with longitudinal pull.

In the first stage the susceptibility is small, and there is almost no retentiveness. In the second stage the magnetism is acquired with great readiness, and much of it may be retained if the force be removed. In the third stage the growth of magnetism is again slow, and what is acquired in it does not contribute much to the residual magnetism. We shall see that these stages are just such as the molecular theory would lead us to anticipate.

§ 172. **Imaginary Molecular Groups.—A Single Pair.**—By way of leading up to the consideration of groups consisting of many magnetic molecules, we may begin by thinking of a group which consists of a single pair. Each member of the pair is to be conceived of as a short magnet capable of free rotation about a fixed centre. In the absence of all external magnetic force this pair of molecules will arrange themselves as in Fig. 137, with opposed poles exactly in the line joining the centres. Let an external magnetic force, H, now be applied in any direction (Fig. 138).

If H is weak the molecules will be but slightly deflected. But as H is gradually increased a stage will be reached at which the molecules part company, and will fly round into a position

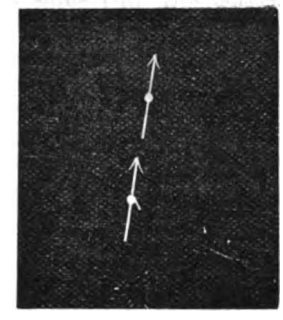

Fig. 137.

in which the direction of the magnetic axis of each is nearly parallel to H (Fig. 139).

Except in special cases perfect parallelism will be reached only when H becomes indefinitely strong.

Then as H is gradually reduced there will at first be little change in the configuration, until a stage is reached at which a sudden return to the condition of Fig. 138 occurs. This will happen at a lower value of H than that which was needed to

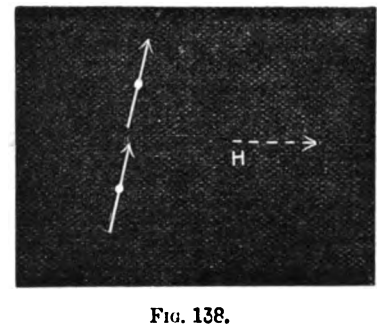

Fig. 138.

break up the group of Fig. 138; here we have, in fact, an elementary example of hysteresis. If the direction of H is chosen so that it is perpendicular to the line of centres this return will occur only when H is reduced to zero. In the more general case, illustrated by the figures, the sudden return will happen when H has a small finite value, and then the subsequent reduction of H to zero will be associated with a gradual change from the state of Fig. 138 to that of Fig. 137.

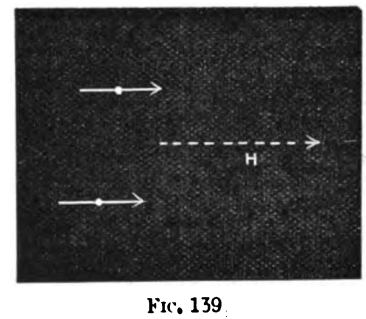

Fig. 139.

During the application of H we have three stages; there is, first, the slight deflection of the molecules (Fig. 138) which precedes what may be called the rupture of the tie that holds them in line with one another. Then there is the sudden swinging into a position of much greater deflection when that tie is broken. Finally there is the continued approach towards perfect alignment, made under strong values of H. During each

* All rights are reserved.

† *See* "Contributions to the Molecular Theory of Induced Magnetism," *Proc.* Roy. Soc., Vol. XLVIII., 1890, p. 342. *Phil. Mag.*, Sept., 1890.

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of these three stages the group is acquiring resultant magnetic polarity in the direction of H, though the magnetisation of the individual molecules is, by assumption, a constant quantity. In the first stage the process is, so to speak, perfectly elastic—that is to say, it corresponds to the elastic stage in the straining of a solid when there is no permanent set left after the removal of the straining force. If we suppose H to be removed at any part of the first stage, the molecules at once return to their primitive positions. But after the critical value of H has been passed, which separates the first stage from the second, this is not so; there is then a tendency to retain the new configuration. We shall see presently that this tendency, which is the very essence of hysteresis, becomes much more conspicuous when we have to deal with larger groups. Finally in the third stage we have again a quasi-elastic part of the process of magnetisation.

To begin with, the equilibrium of the group is, of course, stable with respect to small displacements. Any small casual disturbance, applied and removed, will leave the magnets swinging about the position of equilibrium, shown in Fig. 137. The equilibrium continues to be stable so long as the deflecting force is weak (stage 1). But as the critical point is approached, the stability becomes reduced—just at the end of stage 1 it is neutral, and any further increase of H brings about instability. The molecules then precipitate themselves into the new form (Fig. 139) in which they are once more stable so long as H continues to act.

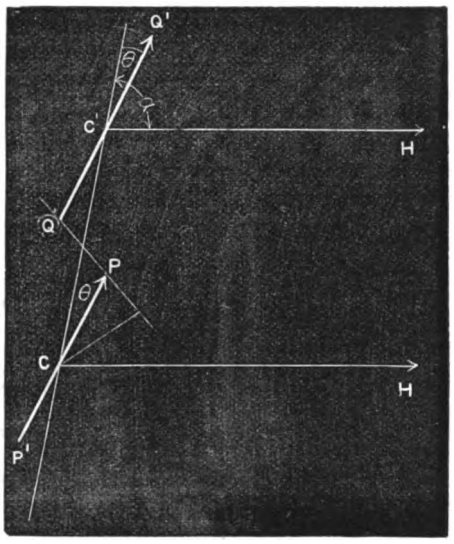

Fig. 140.

To express the matter in symbols, let us suppose that each magnet may be treated as a pair of poles of strength m, separated by a distance $2r$, which is the length of the magnetic axis. Let α (Fig. 140) be the angle which the direction of the applied deflecting force H makes with the line of centres C C', and let θ be the amount of deflection, which is the same for both magnets. It is assumed, in the first place, that H is not so strong as to produce instability.

The field H exerts a mechanical force m H on each pole, or a couple on each magnet, the distance between the parallel forces of the couple is $2r \sin(\alpha - \theta)$.

The deflecting moment which acts on each magnet is, therefore,

$$2\,\mathrm{H}\,m\,r \sin(\alpha - \theta),$$

and this is to be balanced by what we may call the restoring moment, due to the forces which the magnets exert on one another.

These forces are (1), the attraction of the poles P Q; (2), the attraction of the poles P' Q'; (3), the repulsion of the poles P' Q; and (4), the repulsion of the poles P Q'. Of these forces the moments of the third and fourth balance one another, and the moment of the second is insignificantly small compared with that of the first, provided the distance C C' is not much greater than the length of one magnet, and the deflection is not great. Under these conditions it will suffice to consider the restoring moment as due to the first force only, namely, to mutual attraction of P and Q. Its value is

$$\frac{m^2\,\mathrm{C\,N}}{\mathrm{P\,Q^2}},$$

and the condition of equilibrium is that

$$2\,\mathrm{H}\,m\,r \sin(\alpha - \theta) = \frac{m^2\,\mathrm{C\,N}}{\mathrm{P\,Q^2}}. \quad . \quad . \quad . \quad (1).$$

As θ is increased the restoring moment at first increases, but passes a maximum at a value of θ which depends on the relation of the length r, or C P to the length C C'.

When H and θ are sufficiently increased the equilibrium becomes neutral. This occurs when

$$\frac{d}{d\theta}\left\{2\,\mathrm{H}\,m\,r \sin(\alpha - \theta)\right\} = \frac{d}{d\theta}\frac{m^2\,\mathrm{C\,N}}{\mathrm{P\,Q^2}},$$

or

$$\frac{d}{d\theta}\left\{\mathrm{H} \sin(\alpha - \theta)\right\} = \frac{m}{2r}\frac{d}{d\theta}\frac{\mathrm{C\,N}}{\mathrm{P\,Q^2}} \quad . \quad . \quad (2).$$

From these two equations (1) and (2) it is possible to determine the values of H and of θ corresponding to the critical point in the deflection, at which the equilibrium of the deflected molecules become neutral. Any greater value of H will cause instability; the molecules will then swing violently round into a new position of equilibrium with their axes nearly parallel to the direction of H.

If there were a number of such pairs of magnets, all acted on by the same deflecting field, but with their lines of centres inclined at various angles to the direction of H it is clear that some would reach instability sooner than others, as H was strengthened. The first pairs to become unstable would be those which were inclined at something more than a right angle to H, so that $\alpha - \theta$ became a right angle when the value of θ corresponding to instability was reached. Other pairs would escape passing through the unstable state altogether, namely, those pairs which lay initially in directions nearly parallel to H. How nearly parallel to H they must lie initially in order to escape instability depends on the extent by which the distance between the centres exceeds $2r$.

If we suppose that this excess of distance, or clearance between the poles, as one may call it, is very small, then the state of instability in pairs which lie well across the direction of H is reached approximately when

$$\frac{d}{d\theta}\cdot\frac{\mathrm{C\,N}}{\mathrm{P\,Q^2}} = 0,$$

which happens when $\tan\phi = \frac{1}{\sqrt{2}}$, ϕ being the inclination of the line P Q to the line of centres C C'. In these circumstances the value of H which breaks up the pair is

$$\mathrm{H} = \frac{m}{12\sqrt{3}\,.\,(a-r)^2 \sin\alpha},$$

where a stands for half the distance between the centres C and C'.

This does not apply when the line of centres is nearly parallel to H. In the special case when the line of centres has the same direction as H, but the magnets point initially in the direction opposed to H, there is no stable deflection previous to the occurrence of instability. The critical point is reached in such a pair when

$$\mathrm{H} = \frac{m}{8\,(a-r)^2}.$$

The general behaviour of a crowd of groups, each consisting of two magnets, can be readily enough imagined, and still more readily examined by aid of a model. Until the first of the groups breaks up, or the field is increased, we have nothing but quasi-elastic deflection. Then the groups successively reach the critical point, so that a rapid, though not perfectly sudden, development of resultant polarity on the part of the crowd as a whole is observed. Finally, there is a slight and further increase, under the action of stronger fields, as the state of "saturation" is approached.

Again, as the field is gradually reduced many of the groups will return to their initial state. Many others, however, will

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assume new forms, namely, with their poles pointing just the other way from the way they pointed at first, and the effect of these will be to contribute a resultant residual polarity which persists when H is reduced to zero. The application and removal of H will leave a majority of groups pointing, more or less, towards the direction in which the force was applied, although at first there was no preponderance in any direction.

We find, therefore, even in so simple a grouping of magnetic molecules as this—namely, a grouping in isolated pairs—many of the features which are presented in the magnetisation of iron. We find analogues of the first, the second, and to some extent the third stages, which are observed in curves of I and H, and we find evidence of hysteresis and residual magnetism. But a very much more complete reproduction of the phenomena of magnetisation becomes possible, as will be shown presently, if we suppose the molecules to be distributed either continuously or in groups consisting of a considerable number of members.

The behaviour of two-member groups would agree fairly well with what is known to happen in the first and second stages of the magnetising process in iron. It seems, however, to leave too little supplementary magnetisation to be acquired during the third stage. And a more obvious difficulty is, that though two-member groups suffice to account for the existence of some residual magnetism, they fail to explain the high retentiveness which is found in, say, soft iron, where we often find more than 90 per cent. of the induced magnetism surviving the removal of the magnetising force. To account for that, something more is needed than the constraint exercised by each member of a pair on the other member; the molecules must, in fact, form new ties after the old ones have been ruptured, and to allow of that each molecule must have more neighbours than one.

(To be continued.)

PRACTICAL POINTS RELATING TO THE ETHER.

BY S. TOLVER PRESTON.

In connection with the question of the compressibility of the ether, there seems to be much uncertainty and vagueness; and it may be of practical interest to notice some of the opinions in relation thereto. Dr. Lodge, in his interesting articles, "Modern Views of Electricity," mentions this matter; and it is with the desire to advance truth that I venture to comment on some passages in these articles, originally published in *Nature*.

In reference, doubtless, to Sir W. Thomson's theory* of matter, Dr. Lodge remarks in Article 9, *Nature*, August 23, 1888, viz.:—"We already know of a continuous incompressible fluid, filling all space, and we call it ether" (p. 389). In regard to this, I would merely lay stress on the fact (first) that the fluid, being assumed continuous, is, therefore, inferentially incompressible as a possible necessity; but this fluid surely is not the ether? For the passage above quoted might seem to some readers to imply that the *ether* was necessarily incompressible. Now, it is a well-known fact that the fluid by itself is imperceptible to the senses, and therefore, of course, cannot be ether, or what we call "matter," at all. The vortices in the fluid (vortex atoms) constitute the ether, including also matter generally—"gross matter," as it is called. So that this theory of vortex atoms has the advantage of making no distinction between the ether and ordinary matter, excepting, probably, one of dimensions of parts; and both ether and gross matter must in accord therewith be of molecular constitution. Maxwell remarks, in relation to Thomson's theory of matter, viz:—"The ether, if it is the medium of electro-magnetic phenomena, is probably molecular, at least in this sense" ("Encyc. Brit.," 1878, p. 527, &c.).

So it appears obvious that the fact of a "continuous incompressible fluid" existing does not imply that the ether is incompressible. The vortices constituting the portions of the fluid thus differentiated as molecules are what we call "matter" or "ether;" the rest appeals to us no more than empty space would do if the old atomic theory of Lucretius were true. In fact, the modern theory of matter does but little more, as it appears, than explain how atoms can be elastic and not "infinitely hard" according to the Lucretian postulate. Otherwise the modern theory leaves the ancient atomic theory much as it was; and this fact is not, perhaps, realised to the degree* it deserves. The ether atoms are not necessarily assumed in contact, of course, and, therefore, the structure (as far as imagination goes) may be conceived to any extent compressible. What degree of compressibility actually exists (if measurable) it is evidently for experiment to determine, or it is difficult to see what other conclusion is open to us.

Dr. Lodge says, further, viz, "The neighbourhood of gross matter seems also to render ether more *dense*. It is difficult to suppose that it can really condense an incompressible fluid, but it may load it or otherwise modify it so as to produce the effect of increased density. In iron this density reaches its highest known value" (p. 389). This is a practical point; but surely the vague idea of "loading" the ether is unnecessary, and it will probably be conceded that no defined conception attaches thereto. A true mechanical conception of increased *density* of ether in iron can apparently only be arrived at by conceiving the ether compressible† to some extent; and to allow this it is only needful to assume that its constituent atoms are very pliable (elastic) or not in contact. There must be room for gross matter in the ether, and it is not easy to see how matter could move freely through the ether if the constituent atoms of the latter were in contact. The subject is difficult, no doubt, and for this reason is all the more criticism necessary and desirable for elucidation and progress.

But I would just venture to put a question here on a very important and interesting point. Is it proved that the greater magnetic permeability (specific magnetic capacity) of iron is due to the greater *density* of the ether in it? According to this the ether in iron is inferred to be about 300 times denser than the ether in air. If we could prove the truth of the view (which seems highly probable on certain theoretic grounds, no doubt) that magnetic permeability is proportional only to the ether density in a substance, it would certainly simplify matters, and this theory deserves encouragement from its simplicity. But would not additional research be essential to establish this view?

Again, we may much admire the (parallel) theory that the specific inductive capacity of substances is proportional to the elasticity of the ether contained in the substances. But, although some considerations may render this theory probable, is there evidence, it may be asked, that the molecules of the bodies themselves or *their* elasticity have no part in regulating the specific inductive capacity, in addition to the influence of the ether, which unquestionably penetrates all substances? These conclusions would seem to be spoken of in the "Modern Views of Electricity" rather as established facts than as theories. It is then also set forth as an hypothesis regarding the assumed incompressible ether as follows:—"Let us suppose that it is composed of and by electromotive force, analysable into two constituents; let these constituents cling together with a certain tenacity, so that the medium shall have an electromotive elasticity, though mechanically quite fluid," &c. (p. 389). This implies, I assume, that portions of the fluid constituting compound molecules are "analysable into two constituents;" for the incompressible fluid itself can scarcely, of course, be said to be analysable into constituents.

Dr. Lodge in his first article, favouring, as he does, the idea that electricity is a substance, emits the view that "electricity behaves itself like a perfectly *incompressible* substance or fluid" (p. 533).

This fluid—electricity—is supposed to occupy cavities or cells in matter. But surely the *incompressibility* of this fluid makes it impossible to explain the "strains" of static electricity, which Dr. Lodge regards as synonymous with strains of the fluid;

* Known to be based on some mathematical investigations of Helmholtz.

* We are only treating the broadly announced mechanical aspects of the theory here. Of course, I am aware that the fluid about the vortex atom has important functions—conduces by its motion to the stability of the atom, &c., &c. But *roughly* the exterior fluid plays the part of space, (since it is not what we call "matter,") and there can be no doubt that this conception is a very useful and practical one.

† To my mind an incompressible ether is utterly inconceivable—certainly in relation to dynamical ideas.

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and he admits that "the actual changes in volume necessary to the strain of these cavities are a defect in the analogy" (p. 536). But surely this difficulty is absolute or prohibitory, since it is the characteristic of incompressibility not to allow a change of volume. With the idea of meeting this objection, Dr. Lodge then speculates on a "*two-fluid*" theory of electricity; and it is not stated by what physical qualities the one fluid is to be distinguished from the other.

In Article 8 the induction of currents in moving conductors is tentatively illustrated, and the difficulty of conceiving motion through the magnetic field, owing to the *quasi* rigid system of gearing adopted to illustrate the hypothetical magnetic whirls, is freely allowed to be an obstacle in the way of conception. I mention this to show the numerous difficulties there are, and how all classes of mind should be invited to co operate to remove or lighten them. This criticism is far from implying a non-appreciation of Dr. Lodge's articles.

May it not be that the vibrations constituting light are not of a character to condense the ether, while the vibrations about a wire *are*—in fact, here the ether is enchained, as it were; there is no escape, it must condense (and, conversely, rarefy), if condensable at all, by a *radial* vibration about the wire as an axis, or by any enforced tendency thereto. On the other hand, when a body moves through the ether, it can do so without (sensibly, at least) condensing it, because the ether can escape round the sides of the body. No escape, however, when the ether vibrates radially or axially about a wire *which is a closed circuit*. If it were not closed (not a circuit), the ether could, perhaps, conceivably avoid condensation by escaping over the ends. But there are no ends in a circuit. Hence the *rationale* of a circuit, or possibly one function of it. This point is gone into in additional aspects in a former article published in *The Electrician* of August 14th, entitled "Rough Ideas of the Mechanism of the Electric Circuit."

In reference to the constitution of matter, it may be well to keep in mind that we are independent substantially of theories of the nature of matter generally. We have to look to experimental fact, which proves (1) definitely that molecules exist, (2) that the molecules are from *some* cause elastic, or else the conservation of energy could not be true. To show by some theory of the nature of matter, why or *how* molecules are elastic may be (as we may admit) very interesting,* but only having a secondary influence in the industrial applications of science and general theorising relating thereto.

ON THE DAMPING OF ELECTRICAL WAVES AND THE MEASUREMENT OF STATIONARY HERTZIAN VIBRATIONS ALONG WIRES.†

BY PROF. D. E. JONES.

An account was given of preliminary experiments made at Bonn (at the suggestion of Prof. Hertz) on electric waves in wires. The first object was to find a simple method of measuring the disturbance at different points of a wire (or pair of wires), along which are sent waves which interfere, after reflection, at the ends. It was found that measurements could be made by inserting a very small thermo-junction in the circuit at different points, and noting the deflection of a low-resistance galvanometer connected up to it. The method is delicate enough to detect and measure exceedingly small currents, such as those produced by telephones.

The method was next applied to measure disturbances along a pair of wires about 130 metres long. One end of each wire was connected to a (secondary) plate 40cm. in diameter. In the first set of experiments the other (far) ends of the wires were left free. The vibrator was of the usual type, provided with plates of the same size as those on the near ends of the wires and facing them. The wave-length of the disturbance along the wires was about 4·3 metres. The following results were obtained:—

I. The disturbance was zero at the end (0), rising to a maximum (51) at 2·2m. There was no further absolute minimum, *i.e.*, the disturbance did not fall to zero at any point. At about 4·6m. there was a minimum deflection of 11, at 6·7m. a maximum of 46, at 9m. a minimum of 13, at 11m. a maximum of 23, and so on. Thus the waves tail off rapidly. There were two complete strongly marked waves and indications of a third, after which the disturbance tended to become steady along the wire.

II. When the far ends of the wire were joined similar results were obtained, excepting that the positions of maxima and minima were interchanged, the disturbance being, *e.g.*, a maximum at the ends. The results indicate that only a small number of waves are sent out by the vibrator, and that these are rapidly damped. In both the above experiments the primary and secondary plates were 30cm. apart.

III. (Ends joined.) On bringing the secondary and primary plates nearer together the damping became more and more rapid, as if the secondary more quickly absorbed the energy radiated out by the primary. When the plates were 5cm. apart only one wave could be detected.

The above method has the advantage of requiring only the simplest apparatus. The only other published method which has been used for similar purposes is the bolometric method of Dr. Rubens, but Mr. Bjerknes has obtained similar results to those of the author with an electrometer instead of a thermo-junction.

In order to find whether the junction produced any disturbance, loops of wire were inserted at 17m. from the far end; but loops up to a metre long did not appear seriously to affect the positions of the maxima and minima.

MAGNETIC EXPERIMENTS MADE IN CONNECTION WITH THE DETERMINATION OF THE RATE OF PROPAGATION OF MAGNETISATION IN IRON.*

BY F. T. TROUTON.

The object of the experiments was to find whether magnetisation was propagated through iron with a finite speed, and reasons were adduced in the Paper for supposing the speed to be comparatively slow—more like that of sound than that of light.

The first experiment was made with an iron bar carrying at its ends oppositely-wound spirals, through which the same alternating current was passed. Between these was moved (coiled round the bar) a third exploring coil E (Fig. 1), connected to a

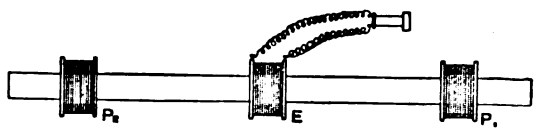

FIG. 1.

telephone. Faint indications of places of minimum intensity were obtained with the bar.

It soon became evident that if any interference-phenomena really existed, they could more simply be obtained by using an iron ring (*see* Fig. 2) with a *single* primary P coil on it. The rings were of various sizes, from 8ft. to 47ft. in circumference, and were made of iron wire—about No. 30—some four miles of it. Nodes and internodes were found in the half of the ring remote from the alternating coil. It was easily ascertained that these were not the nodes looked for, because they did not depend on the rate of alternation. The distance between the

* A true theory of the nature of matter may also, doubtless, have deductive consequences capable of being put to an experimental test, and such a theory, if true, may conceivably be some aid to theoretic thought; but certainly facts numbered (1) and (2) above are the chief practical points for us of real value in research.

† Abstract of Paper read before the British Association, in Section A, at Cardiff, August, 1891.

* Abstract of a Paper read before the British Association, in Section A, at Cardiff, August, 1891.

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nodes was 10-18 inches. A ballistic galvanometer gave no indication of nodes, but always gave deflections in the same direction. The results were the same when an ordinary alternator, a rotating commutator, or an organ-pipe and microphone was used. There were four or five nodes in a 10ft. ring (about 2,000 turns of wire).

In the discussion which followed, Dr. Lodge and Dr. Larmor both expressed an opinion that the results obtained were due to mechanical vibrations exerted by magnetism, or to differences

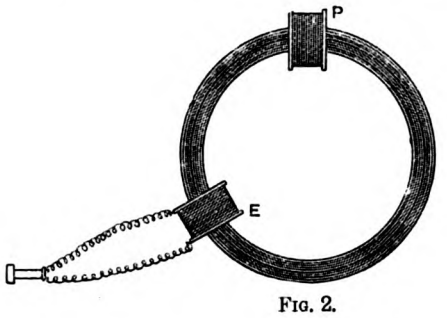


FIG. 2.

in annealing. This might explain the fact that the nodes were only obtained when the primary coil was in certain positions. But Prof. Rücker pointed out that, inasmuch as the ring was of coiled wire (not bar), an original magnetisation of the ring in the first experiment was a more probable explanation.

ON THE MAGNETIC FIELD IN THE NEIGHBOURHOOD OF THE SOUTH LONDON ELECTRICAL RAILWAY.*

BY PROFS. AYRTON AND RÜCKER, FF.R.S.

In the spring of the present year we were both interested in the question as to how far the work of a physical laboratory would be affected by the neighbourhood of an electrical railway.

The South London Electrical Railway runs from Stockwell to the City. It is constructed under the public road at a depth of 60 or 70ft. below the surface. The up and down lines are carried in separate tunnels and enclosed in large iron tubes. The current is conveyed to the trains by an insulated rail, and the circuit is completed through the rails on which the trains run, which probably are or were themselves in communication with the iron tubes and thus with the earth.†

Our observations were made at a house (No. 122) in Kennington Park-road, under which the railway runs, in two rooms, at points distant about 60ft. and 200ft. from the middle of the road respectively.

The instruments used were (1) a rough magnetometer, consisting of needles attached to a mirror suspended by a silk thread about three inches long; and (2) an ordinary Elliott's square pattern mirror galvanometer which was used as a magnetometer.

All observations were made when the period of vibration of the instrument used was about 10 sec. To compare the magnetic disturbances with those due to mere mechanical vibrations, the magnets were removed from another similar galvanometer, and replaced by copper rods of about the same mass. The mirror was then suspended by a bifilar which gave a period of about 10 sec. This was only intended to detect the effects of shaking on the galvanometer, and it may be sufficient to say that it proved conclusively that, at Kennington Park-road, the tremors due to the traffic might be almost neglected as sources of disturbance when compared with the magnetic effects of the railway.

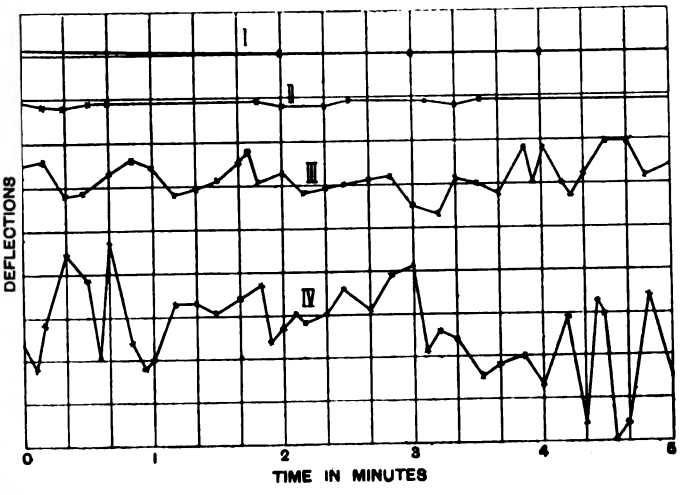
The latter were continuous and very great. On one occasion, when the line was blocked, the instruments were at rest. The oscillations began again at or within a few seconds of the time when a train which had been detained in the neighbouring station left it. This coincidence was most satisfactorily established, as some of our party were noting the times of the arrival and departure of the trains, while others were also noting the instants at which the largest disturbances of the instruments occurred.

The passage of a train caused a very sudden disturbance of the needle, especially in the room nearest the line; but the amplitude of these vibrations, though greater, was often not much greater than that of those which were continually occurring at other times.

At 60 feet from the middle of the road the larger deflections produced on a scale one metre distant from the instruments were about ±20 mm. At the more distant position, about 200 feet from the road they were about two and a-half times less.

As the instruments were about 10 feet above the roadway, and probably about 70 feet above the line, the distances from the line at the two stations were roughly $\sqrt{60^2+70^2}$ and $\sqrt{200^2+70^2}$, or 92 and 212 feet respectively. The ratio of these numbers is 2·3, and as the ratio of the disturbances at the two stations was about 2·5, it is evident that they diminish very slowly as the distance increases. The law of the inverse distance was apparently approximately fulfilled.

To show the effects of the railway we publish the comparative diagrams in curves I. to IV.



Curves showing Magnetic Disturbances caused by the operation of the City and South London Railway.

Readings of an Elliott's galvanometer arranged as above described were taken every 10 seconds in (1) a laboratory of the Royal College of Science, about 150ft. west of the middle of Exhibition-road; (2) another laboratory about 70ft. east of the same road; (3) a room at Kennington Park-road about 200ft. from the middle of the road; (4) a room at Kennington Park-road 60ft. from the middle of the road.

Curves I. to IV. show the results at each place, and the ordinates being the actual deflections observed.

The irregularities in Curve II. were no doubt due to a dynamo which was working at some distance. Curves III. and IV. show the effects of the railway and prove conclusively that ordinary students' work would be impossible in its neighbourhood. To emphasize the fact that the standard of sensitiveness adopted was very moderate we may mention that one of the instruments arranged as for the experiments was compared with a small magnetometer constructed by Prof. Boys, F.R.S. The latter instrument was found to be 160 times more sensitive than that employed in the observations just described.

A Lightning Conductor in 1783.—According to *La Lumière Electrique* a curious discovery has recently been made in the shape of a speech by Robespierre, occupying 100 printed pages, in defence of the Sieur de Vissery, who was appealing in 1783 against a judgment delivered by the Sheriffs of Saint-Omer ordering the destruction of a lightning conductor erected by him. The appeal was, we are told, successful.

* Paper read before the British Association, in Section A, Cardiff, August, 1891.

† We believe that some alterations have been made since the date of our experiments.

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COMPETING TELEPHONE COMPANIES.

Although never approving of the system of license under which the Telephone Companies have been working, we have always held that the arrangement had one supreme merit—it prevented competition. Competing telephone systems in one and the same town appeared to us, on many grounds, to be intolerable, and, for obvious reasons, incapable of being worked to public advantage. The mere granting of a license seems to convey a virtual, if not strictly legal, monopoly, the acceptance of a fee from one party implying that it will not be accepted from any other party for the same privilege. Probably the licensing system was accepted in the first instance on some general understanding of that kind, an understanding amounting to this, at least, that so long as the privilege was exercised in good faith, the holder need have no fear of its being interfered with Besides this, the peculiar character of the business rendered competition impossible, except in the extreme case of a licensee grossly neglecting to carry out the object for which he obtained the license. A fairly complete telephonic system cannot be invaded by a rival system without detriment to both; and as no telephone system is of much account unless it is complete—that is to say, covers all the ground, and responds to all requirements as they arise—it follows that there is no room for a second, and if allowed to begin, its operations will only serve to impair the usefulness of the system in possession without supplying its deficiencies. Add to these reasons the intense disgust provoked by the doings of one Telephone Company in the matter of overhead wires, and we feel sure that few people ever dreamed of another Company being allowed to set its foot in the streets of London.

If, however, we are to credit the Duke of MARLBOROUGH, all these confident predictions are to be knocked on the head, for it is said that a new Company, possessed of a license from the POSTMASTER-GENERAL, is about to commence business in the Metropolis, and is preparing a Bill for Parliament next Session "with the object of establishing a complete twin-wire tele-"phone service for the whole of London on the basis of a £10 "a year rental." As the consent of Parliament is not required either for a "twin-wire" service or a "£10" rental

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we are led to infer that the Company will seek powers which the existing London Company does not possess. From further letters of the noble Duke we conjecture that what will be sought is the power to break up streets for the purpose of laying down underground wires. All we need say as to this is that if the old Company does not check the move by seeking similar powers for themselves, it will be their own fault if they suffer a little sharp competition. Mr. FAITHFULL BEGG, whose letter to *The Times* we printed last week, is at great pains to throw all the shortcomings of the telephone upon the Post Office; but as regards the one place where these shortcomings are most conspicuous—indeed, the only place where grievous complaints have arisen—namely, in the Metropolis, he confesses that gross mismanagement, errors of construction, want of foresight, and bad workmanship, are the cause of all the mischief. As to the overhead wires and the consequent evils of circuitous routes and disturbing currents, he dismisses the subject with the calm assertion that "powers to build subways do not exist." We do not remember that they have ever been vigorously demanded, although from the very first the United Telephone Company have been constantly urged to make provision against the time when their housetop wires would become a public nuisance and an impracticable burden to themselves. Notwithstanding these warnings, the hand-to-mouth system with which the business began was persisted in until the task of rearrangement and redistribution has become too gigantic to contemplate, and the cost of placing the wires underground too heavy to be borne. A new Company, warned by this painful example of shortsightedness, would naturally desire to have its main wires, and plenty of them, in undisturbed security underground; and we hope that the powers to do so may be obtained if only to convince Mr. BEGG that if they do not exist already it is nobody's fault but the Company whose interests he is now trying to defend against a threatened competitor.

The financial prospects of such competitor may be safely left to the two parties concerned. The figures adduced in support of the new venture by Mr. CAMPBELL SWINTON in a letter to *The Times*, which we print in another column, will give Mr. BEGG some trouble, we suspect; but there is plenty of time between now and next Session of Parliament to have the question of cost and earnings thoroughly threshed out. Long before then, probably, the Duke of MARLBOROUGH and his friends will have realised what is the extent of the task they are undertaking. It is nothing less than that of supplanting, and one may say extirpating, the enormous telephone system with which this great Metropolitan area is at present served. For nothing short of that will avail. The division of this vast region into topographical sections, as described by Mr. BENNETT in his British Association Paper last month, is undoubtedly the right thing to do, and the absence of such systematic subdivision has been a grave defect of the existing arrangement; but it should be clearly understood that not until each of these sections is complete in itself, and connected with every other section, can they be opened for business at all. Further, that customers will have to be induced to come in before any business can be done; and before customers at one end can be attracted, customers at the other end will have to be drawn in, with whom the other customers wish to speak. Twin wires and half rates are seductive baits; but they would be esteemed dear at any price if the service were limited or less comprehensive than it is at present. In short, if the new Company are prepared to embrace all London in a network of telephone wires, of superior capacity and cheaper in price; if, when this is completed—not until then—they will say to the National Telephone Company, "Stand and deliver!" and to its customers, "Come over to this shop!"—if this is what the promoters intend doing, well, they are a very courageous set of men. Falling short of this ideal, the opposition might make things rather unpleasant for the London Company; and this would no doubt please the Duke of MARLBOROUGH, who, besides being enamoured of the new system, says very unfriendly things about the old. But shareholders invest their money with the idea of earning profit, not of vexing an opponent; and we suppose that the noble Duke is not alone going to finance this twin-wire, underground, ten-pound, London telephone system.

In all seriousness, we should very much like to learn on what conditions the POSTMASTER-GENERAL was induced in 1884 to admit a competing Company within the Metropolitan limits. So just and reasonable a man would never have taken such a step without great provocation, or the strongest conviction that this was the only way open to him of bringing the telephone system into something like order and efficiency, and within the reach of everybody fairly entitled to use it. From a further letter of the Duke of MARLBOROUGH, which we print this week, it seems that the New Company's license is an "All England" one; but that it was pointedly aimed at the capital City. If that is the case it may have been thought even then that the old Company had had a long enough innings, and ample time to provide against contingent competition. But be this as it may, the course which would have been preferred by the public was that of a frank and direct opposition directed by the Post Office itself, on the justifiable plea that as the license was not exercised to the satisfaction of the Metropolitan public, the Government would perform the work itself, giving the old Company the choice of severe competition, or sale at a fair price. The moment has passed, we fear, for this; but surely it is not too late to avert a species of competition which cannot fail to be disastrous to all the interests concerned. The plan of Mr. BENNETT, the devices of Mr. MANN, and the aspirations of the Duke of MARLBOROUGH are all excellent things in themselves, and we hope to see them introduced successfully even into London; but it is very late in the day to start these reforms, and those who are responsible for neglecting them so long should at any rate save us from the chaotic consequences of any ill-advised or precipitate introduction of them now.

OBITUARY.

LOUIS JOHN CROSSLEY.

We have to record with great regret the death of Mr. Louis John Crossley, which occurred at Halifax on August 30th. Although one of the earliest members of the Society of Telegraph Engineers, fellow of the Royal Meteorological Society, an inventor of very considerable success, and regarded in the North as a high authority on electrical and mechanical engineering, yet, on account of his retiring disposition and modesty, he was seldom to be seen in scientific gatherings other than those which he so ably assisted in his own town and the neighbourhood. Mr. Crossley was the only son of the late Mr. John Crossley, of Manor Heath, Halifax, and grandson of the founder of the enormous carpet-making industry at the Dean Clough Mills, the largest carpet works in the world. Born in 1842 he began to work at Dean Clough at the age of 17, and acquired an intimate knowledge of textile machinery engines, and the use of steam. He soon became thoroughly acquainted with the construction of engines and boilers, and ultimately this department came under his personal supervision. From time to time he introduced improvements, was ever on the alert for inventions; and there is no doubt that the excellent character of the machinery for

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which Dean Clough has been famous for many years has been largely due to the skill and judgment displayed by Mr. Crossley.

His early acquaintance with electrical science is proved by his having delivered, at the age of 18, a lecture on the electric telegraph, when he showed a number of experiments, messages being sent to the works and offices, a time ball, and electric light from a battery being exhibited. The development of this early and practical acquaintance with telegraphy is to be found to-day in the very complete equipment of the Dean Clough Mills, where there are about 110 telephone and telegraph circuits and a well-fitted exchange, to which private wires from the post-office and neighbouring towns are connected. A feature in the entrance hall of his house at Moorside was a complete set of telegraph apparatus, and a telephone exchange in connection with Dean Clough Mills and the local company. He took a keen interest in meteorology, and expressed a hope that it might soon become one of the exact sciences. One of his earliest inventions was the Crossley Recording Anemometer, and the last time we saw him, during the distressing mental illness which commenced five years ago, he seemed to go back with more pleasure to the numerous meteorological instruments which were conspicuous in his garden, on the roof, and connected to the elaborate recording instrument in the hall, than to his electrical laboratory and workshop. Had it not been for the numerous duties which he undertook, and under the burden of which he broke down, he might have made the Moorside Laboratory famous as the scene of valuable research, for it was fitted with nearly every appliance that could be desired for electrical measurement, and was supplemented by a chemical laboratory, a well-furnished workshop, engine-room, dynamos, motors, and a battery-room. On the roof is a search light, provided with graduated circles; and, close at hand, a table with the bearings of numerous houses in the neighbourhood, taken during the day by a theodolite, and thus he used to turn the beam into the windows of his friends' houses at night. In his garden was laid a miniature electric tramway, worked by the dynamo in his house. It was on this line that Mr. Holroyd Smith made his first experiments in electric traction.

In 1864 he was busy with telegraphy and patented a telegraph insulator, and in the following year, in conjunction with M. Breguet, he patented an improved form of A B C telegraph, of which many thousands were sold.

Mr. Crossley exhibited the electric light in Halifax in 1875, borrowing the large Gramme machine which had been used for showing the signal light on the Clock Tower at Westminster, and shortly afterwards built a dynamo for lighting his works. A 6-light Brush was added, and in 1878 a Siemens machine, and when modern dynamo making was emerging from the old rule-of-thumb work, he took an eager interest in every improvement, and spent great pains in perfecting the electric lighting at Dean Clough Mills, his own house, and the Lancashire and Yorkshire Railway station at Manchester.

"The announcement of Prof. Graham Bell's invention of the telephone," says the *Halifax Courier*, "took everyone by surprise. Mr. Crossley, always on the alert, secured the first telephone that came to this country, and had it fixed to the wires existing at Dean Clough in place of the Crossley-Breguet instruments which were then in use. As in the case of the other inventions and discoveries, he was early at work lecturing in Halifax, Brighouse, Huddersfield, and other places, explaining and illustrating this latest development of electrical science. Finding that the telephone lacked that efficiency which was required to make it useful for commercial purposes, Mr. Crossley set himself to improve it, and ultimately brought out and patented the 'Crossley Transmitter,' by means of which the message delivered was more audibly carried to its destination. One remembers well the early stages in this development, how experiments were made in Square Church and other places, and the delight one experienced on a certain Sunday evening when, going over to Bradford, one heard there the sonorous tones of Dr. Mellor announcing the hymns and preaching in his own church, eight miles away; and when, also, the singing of the congregation could be heard with equal distinctness. The invention proved very remunerative. It was so completely satisfactory that the United Telephone Company, who held the Bell, Edison, and other leading patents, made overtures to Mr. Crossley, and ultimately gave him £20,000 for his patent."

Besides inventions connected with spinning, oiling, and carding wool, printing blocks, &c., he invented an electric engine indicator, and was associated in the invention of a system of train lighting and dynamo brush holders. His most widespread invention is the enamelled water-gauge glass for boilers, and a curious outcome of this is a glow lamp, with a bulb blown from this kind of glass, one side being opal, the other clear. The effect is extremely good, but the state of lamp patents has prevented its popular use. A man of unusual energy and capable of concentrating himself thoroughly on one thing at a time, his early death was due to incessant work, much of it being of a voluntary character. He was, at the same time, Justice of the Peace both for the county and the borough, a director of the Lancashire and Yorkshire Railway, President of the Halifax Literary and Philosophical Society, member of the Chamber of Commerce, officer of more than one political association, Colonel of the 2nd West York Volunteers, director of the huge Dean Clough Works, and president and founder of its Choral Society. He was a skilful organist, and had a good knowledge of organ construction, and often fulfilled the duties of organist at his church.

Until five years ago he had, to all appearance, a long life before him, but one after another of his public duties was given up. He went round the world in the hope that the sea voyage would restore him, particularly as he was an ardent yachtsman. His death was quiet, and occurred after an attack which left him unconscious. His loss is keenly felt in West Yorkshire, where he was esteemed as a most genial and sympathetic man, approachable by everybody, and known by all his workpeople as "Louis John." He was wont to declare himself to be only an amateur in science and engineering, and regarded these studies as a hobby; but he has left his mark in the North, as much for his scientific work as for his other pursuits. He leaves eight children, one of whom is studying engineering.

THE DETERMINATION OF CURRENTS IN ABSOLUTE ELECTRO-MAGNETIC MEASURE.

BY G. F. C. SEARLE, M.A.

§1. In this series of articles it is proposed to give an account of some determinations of the quantitative chemical effects produced when an electric current flows through an electrolyte. This subject is of interest at the present time, owing to the action of the Board of Trade Committee in this matter. The Committee has agreed to the following resolution: "That an unvarying current which, when passed through a solution of nitrate of silver in water, in accordance with the specification* attached to this report, deposits silver at the rate of 0·001118 of a gramme per second may be taken as a current of one ampere." One of the most important researches on the subject of the relation of the ampere to the amount of silver which it deposits per second is that of Lord Rayleigh and Mrs. H. Sidgwick on the Electro chemical Equivalent of Silver (*Phil. Trans.*, Royal Soc., 1884, p. 411), and it is to this research that we shall chiefly confine our attention. The methods of determining the amount of silver deposited are easily understood, but it is much more difficult to obtain a clear idea of the methods and principles employed in the determination of the current in terms of the fundamental units of length, mass, and time; and, consequently, in the minds of many people this part of the subject is surrounded by a good deal of difficulty. In the hope of making the subject of the measurement of currents in absolute electro-magnetic measure a little clearer, some preliminary consideration, from an elementary point of view, will be given to some of those dynamical properties of an electric current upon which the measurements are made to depend.

§2. First, as to the system of fundamental units employed. These are the Centimetre, the Gramme, and the Second. In all strictly scientific work, the "Centimetre" is taken to be the one-hundredth part of the distance at 0°C., between two marks

* See *The Electrician*, July 24, 1891 p. 325.

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engraved on a platinum bar preserved at Paris and known as the "Mètre des Archives." The "Gramme" is taken to be the one-thousandth part of the mass of a piece of platinum preserved at Paris and known as the "Kilogramme des Archives." The "Second" is the mean solar second. This depends upon the rate of rotation of the earth upon its own axis and upon its rate of rotation round the sun. Both of these rates are being altered very slowly by the action of tidal friction, but the change is too small to be detected. For the present the earth will have to continue to be our timekeeper, since we have not yet been able to make a practical clock out of a vibrating sodium molecule whose period of vibration we might suppose would remain absolutely unchanged. The Board of Trade Committee is considering the resolution:—"That by the terms centimetre and gramme are meant the standards of those denominations deposited with the Board of Trade" (*The Electrician*, Feb. 13, 1891). The Board of Trade standards are, of course, known very accurately with reference to the Paris standards, and for all commercial purposes no fault can be found with the resolution. But it must be remembered that the knowledge of the values of the Board of Trade standards in terms of the Paris standards is derived from experiment, and is therefore affected by the inevitable errors of experiment. And it does seem to be a great pity, from a scientific point of view, to have two standards of both length and mass. Thus, on the one hand, we shall have the "Board of Trade centimetre" and the "Board of Trade gramme," and on the other, the "Mètre des Archives" and the "Kilogramme des Archives." It is, however, only in work of the very highest accuracy that it will be necessary to specify to which pair of standards the measurements are referred.

§ 3. Having now settled our fundamental units we proceed to deal with the derived units. We elect to work upon a system of derived units which introduces the smallest possible number of numerical factors into our equations, and, having made this decision, we have no longer a free choice in the matter of the derived units. Thus, a force might be measured in terms of some arbitary unit, such as the force required to produce a definite extension of a Board of Trade standard spring balance, or the force exerted by the earth upon some standard lump of matter at some standard locality. Experiments on dynamics would then show us that we could write down the important relation $P = k m f$, where P is the force, measured in "Board of Trade units," which, acting on a body whose mass is m grammes, produces in it an acceleration of f centimetres per second per second, and k is a numerical factor depending upon the Board of Trade unit of force and only discoverable by experiment. If the equation is to be made as simple as possible, the Board of Trade unit of force must be abandoned, and the unit of force must be defined in the following way: "The unit of force, the Dyne, is that force which, acting upon a mass of one gramme, produces in it per second a velocity in its own direction of one centimetre per second." By experiments with pendulums, the weight of a gramme at any given spot may be calculated in dynes. It is found to be *about* 981 dynes. On account of the variation of gravity, if the results are to be of greater accuracy than ·5 per cent., the locality at which the determination is made must be specified. The unit of work is the Erg, and is the work done when a dyne displaces its "point of application" through one centimetre in the direction of the force.

§ 4 The above example illustrates the manner in which the choice of electric and magnetic units is limited. We shall now go on to develop the electro-magnetic system of units, always keeping before us the principle that the units are to be so chosen that the equations of the subject may be as simple as possible.

Unit Magnetic Pole.—It is found that two magnetic poles of the same signs and of strengths m and m', measured in terms of some standard pole, when placed at a distance r centimetres apart, repel one another with a force $\alpha \frac{m m'}{r^2}$ dynes, when α is a numerical factor depending upon our choice of standard pole. If we wish to make $\alpha = 1$, and so simplify the equation as much as possible, we must define a unit pole in the following way: "A unit magnetic pole is such that when placed at a distance of one centimetre from an equal and similar pole it repels the second pole with a force of one dyne." By a north* pole we mean the pole which points to the north, and we consider this as the positive pole. It is, of course, impossible to make experiments with isolated magnetic poles, since every magnet has two equal and opposite poles; but the experiments of Gauss upon *magnets* proved that they behaved as if the forces between their poles obeyed the law stated above.

§ 5. **Magnetic Moment.**—When we deal with a magnet as a whole, it is often sufficient to know the product of the strength of either pole and the length of the magnet. This product is called the magnetic moment of the magnet, and completely defines the magnitude of its action at any point whose distance from the magnet is great compared with the length of the magnet when we know the angle between the magnet and the line from its centre to the distant point. Thus the action at distant points and also, as we shall see below, the couple

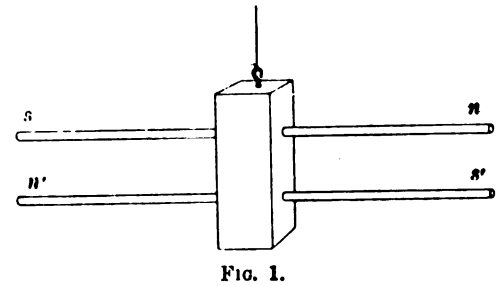

Fig. 1.

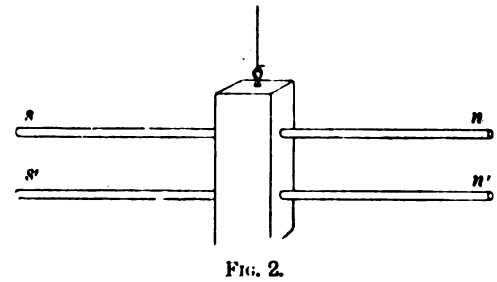

Fig. 2.

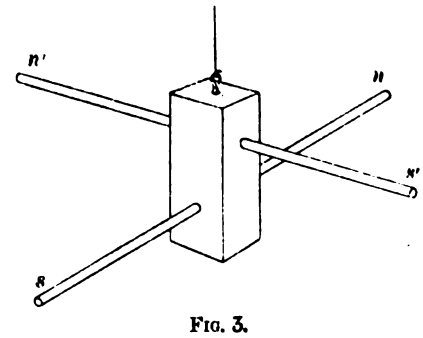

Fig. 3.

experienced by the magnet when placed in a uniform magnetic field, is completely known when we know both the numerical magnitude of the magnetic moment of the magnet and also the direction of the axis of the magnet, *i.e.*, the direction of the magnetic moment. Thus we are led to see that the magnetic moment of a magnet is a vector quantity, and we are then at liberty to apply all the laws of resolving and compounding just as we do to forces in the study of statics. The direction of the magnetic moment is the direction from the south to the north pole of the magnet. The method of resolving magnetic moments is often most useful in attacking problems on the action of small magnets. The following experiment, devised by the writer for the class at the Cavendish Laboratory, affords an example of the composition of magnetic moments. A small block suspended by a fine fibre supports two small magnets, $n s$, $n' s'$. Holes are bored in the block so that the magnets can be placed either parallel, as in Figs. 1 and 2, or at right angles to each other, as in Fig. 3.

* Sir William Thomson, following Dr. Gilbert of Colchester, would call this a true south pole, it being of the same sign as that magnetic pole of the earth which is situates in the Antarctic regions.

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Each magnet is made of a half knitting needle. The moment of inertia of the system about the axis of suspension, of course, remains the same in all three cases. Let H be the horizontal strength of the earth's magnetic field, m, m' the magnetic moments of the two magnets and M_1, M_2, M_3, T_1, T_2, T_3 the resultant magnetic moments, and the times of vibration in the three cases. Then it follows at once by the parallelogram law that $M_1 = m - m'$ $M_2 = m + m'$ $M_3 = \sqrt{m^2 + m'^2}$.

Let K be the moment of inertia of the system, then, as we shall explain later, the times of swing will be given by

$$T_1 = 2\pi\sqrt{\frac{K}{M_1 H}} \quad T_2 = 2\pi\sqrt{\frac{K}{M_2 H}} \quad T_3 = 2\pi\sqrt{\frac{K}{M_3 H}},$$

whence, $$\frac{M_2}{M_1} = \frac{T_1^2}{T_2^2},$$

and therefore, $$\frac{m}{m'} = \frac{T_1^2 + T_2^2}{T_1^2 - T_2^2}.$$

Now, in case (3), the resultant magnetic moment must be along the magnetic meridian when the system is at rest. Mark upon a sheet of paper, placed close beneath

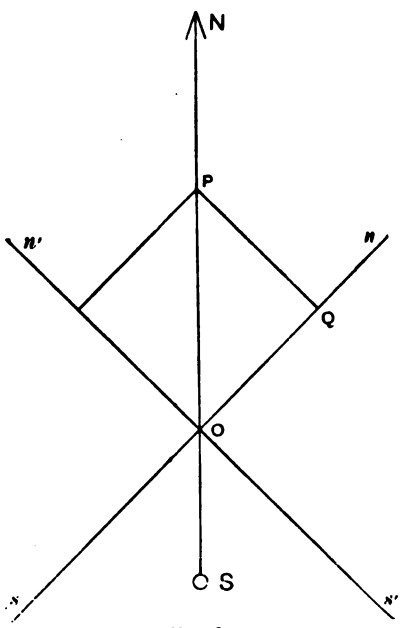

Fig. 4.

the system, the direction of the meridian N S and of the magnets in case (3). Draw P Q (Fig. 4) perpendicular to n s, then if the parallelogram law holds good, $\frac{OQ}{QP} = \frac{m}{m'}$, and therefore, $\frac{OQ}{QP} = \frac{T_1^2 + T_2^2}{T_1^2 - T_2^2}$. Experiment shows that this relation is fulfilled, and that the parallelogram law gives the correct *direction* for the resultant magnetic moment. By observing the value of T_3, we can test the correctness of the *magnitude* of the resultant given by the parallelogram law. For by this law $M_3^2 = m^2 + m'^2$, and, therefore, $2M_3 = 2(m^2 + m'^2) = (m + m')^2 + (m - m')^2 = M_1^2 + M_2^2$,

whence, $$\frac{2}{T_3^4} = \frac{1}{T_1^4} + \frac{1}{T_2^4}.$$

Experiment shows that this relation also is fulfilled, and, therefore, that the parallelogram law gives the correct magnitude for the resultant magnetic moment. We have shown that the magnetic moment of a magnet is a vector quantity, and, accordingly, if we find it useful to do so, shall not hesitate to apply the parallelogram law.

§ 6. **Magnetic Field.**—Any region of space at any point of which a magnetic pole experiences any force (depending upon its being a magnetic pole) is called a magnetic field. The strength of a magnetic field, or the magnetic force at any point, is measured by the mechanical force in dynes which a unit north pole experiences when placed at the point under consideration. The direction of the magnetic field is the direction of the force experienced by the pole. We see that the strength of a magnetic field is a vector. If H is the strength of the field and m the strength of a pole, then the force experienced by the pole is m H dynes. Hence the strength of the field or the magnetic force at a distance r from a pole of strength m is $\frac{m}{r^2}$, for the force experienced by a unit pole at that distance is $\frac{m \times 1}{r_2}$ dynes. The direction of the magnetic force is along the radius drawn from m.

We will now find the couple experienced by a magnet when placed in a uniform magnetic field. Let H be the strength of the field, M the magnetic moment of the magnet, m the strength of each pole, $2l$ the length of the magnet, θ the angle between the direction of H and the direction of M. Each pole experiences a force m H dynes in a direction parallel to that of H. The two forces acting in opposite directions produce a couple whose moment is m H × (perpendicular distance between the two forces), or m H·$2l$ sin θ. But $2ml = M$ by the definition of magnetic moment, and, therefore, the couple = M H sin θ. The axis about which the couple acts is at right angles both to the axis of the magnet and to the direction of the magnetic field.

Note.—The axis of a couple is always to be drawn in such a direction that the direction of the axis and the direction of the rotation which the couple tends to produce are related in the same way as the motion of translation and the rotation of a right-handed screw when working in a fixed nut.

In the present case, since the magnetic force and the axis of the magnet are both in the plane of the paper, the direction of the axis of the couple is outwards from the paper.

If M is placed at right angles to H then the couple becomes simply M H. Thus we can measure the strength of the field at

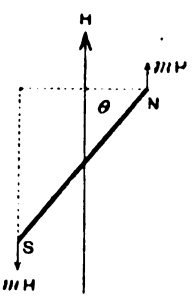

Fig. 5.

any point by the maximum couple which a small magnet of unit magnetic moment experiences when placed at the point. This is a more *real* method than that of finding the force acting on an isolated unit pole. Again, if the angle between M and H is very small we may write θ in place of sin θ, and then the couple = M H θ. Let K be the moment of inertia of the magnet, then the angular acceleration which this couple produces in the magnet is $= -\frac{M H \theta}{K}$ in the direction in which θ increases. By the principles of simple harmonic motion we see that the magnet will vibrate and that the time of swing will be $T = 2\pi\sqrt{\frac{M H}{K}}$. This expression enables us to find M when we know H, and *vice versa*.

§ 7. **Lines of Force.**—The conception of lines of force is due mainly to Faraday, and is of very great assistance to us in aiding us to form mental pictures of electro-dynamic phenomena. Taking any point of the magnetic field as a starting point, draw a curve such that at each point of the curve the magnetic force is in the direction of the tangent to the curve. This curve is called a line of force. A small magnet free to turn always places itself along the direction of the magnetic force, and, therefore, if placed with its centre at any point of the field will indicate the direction of the tangent of the line of force through that point. Iron filings serve the same purpose, since they become

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magnetised in the direction of their length and then place themselves along the lines of force. Valuable information as to the state of the magnetic field can often be obtained by the use of iron filings. If we draw a large number of lines of force in the field we can employ them to indicate not only the direction but also the strength of the magnetic field at each point. In order to show how the lines, when properly drawn, can indicate the strength of the field we must employ an important proposition due to Prof. Sir G. G. Stokes. We shall have to make use of solid angles here, and also later on when we deal with electric currents, so that a definition of a solid angle is necessary.

§ 8. **Solid Angles.**—The solid angle subtended by any surface at a given point is measured in the following manner:—Let a radius from the given point travel round the boundary of the surface. Describe about the given point a sphere of one centimetre radius. As the moving line travels round the boundary of the surface it will trace out a curve on the surface of the sphere. The area of this curve in square centimetres is the measure of the solid angle subtended by the surface. If the point is completely surrounded by the surface the solid angle is the same as that subtended by the surface of a sphere at its centre. Since the surface of a sphere of radius r centimetres is $4\pi r^2$ square cm., the surface of a sphere of one centimetre radius is 4π square cm. Accordingly 4π is the measure of the solid angle subtended by any closed surface at any point within it. It might be thought that the solid angle in this case would be zero, but one can easily see that this is not the case by considering the growth of the surface from a very small patch up to the surface completely surrounding the point. The solid angle subtended by an infinite plane at any point near it is clearly the same as that subtended by a hemisphere at its centre, *i.e.*, 2π.

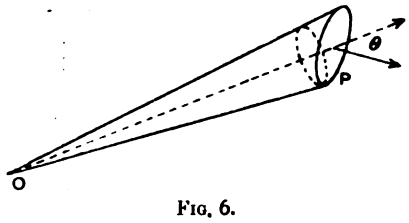

Fig. 6.

If the point is *outside* the closed surface, then, by considering the change in the solid angle as the surface grows from a small patch into the complete closed surface, we see that the solid angle must be considered zero.

We will now find the solid angle subtended by a small plane area at any point. Let O (Fig. 6) be the point, P the small surface whose area is a, and let $OP = r$. Let a radius from O go round the boundary of P, thus describing a slender cone whose solid angle is ω. Let the normal to P make an angle θ with the radius O P. Through P draw a section of the cone at right angles to O P; the area of this section is $a \cos\theta$ since the angle of the cone is exceedingly small. But the surfaces of spheres included in equal solid angles are as the squares of their radii. Hence the area on the sphere centre O and radius 1 centimetre is $\frac{a\cos\theta}{r^2}$ square cm. Accordingly, $\frac{a\cos\theta}{r^2}$ is the solid angle subtended by the area a at O.

(To be continued.)

SAFETY MINING CABLE.

The use of properly protected electric motors has become now a recognised means of transmitting power even in fiery mines; but many colliery managers still object to the introduction of electricity into their collieries owing to the possibility that exists that the cable may be broken by falls of roof or stone, or by the tubs leaving the rails and tearing down the cable, and thus setting fire to the timbers or firing the pit. With a view to removing altogether this danger, Messrs. W. T. Goolden, Woodfield Works, Harrow-road, who for some years have made electric machinery a speciality, are introducing a "safety mining cable" invented by Mr. Ll. B. Atkinson.

The diagrams and figures with the following explanation show the principles on which the cable is constructed. In Fig. 1, A A are the two poles, say, of the generating dynamo, and B B are the two poles of the motor or lamps. These are connected each by two wires, a main conductor, L, and a sub-

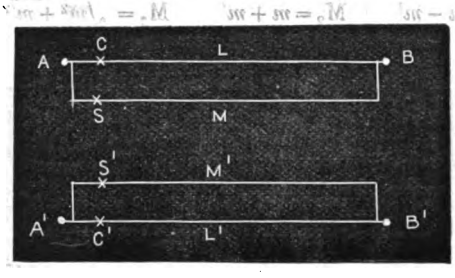

Fig. 1.

sidiary conductor, M. These wires will, of course, carry current simply in proportion to their areas, being of the same length. In each main and each subsidiary conductor are arranged cut-outs proportioned to the carrying capacity of each wire. Suppose the main conductor, L, be broken, provided that the subsidiary conductor, M, is not broken, no spark will result at breaking, as the circuit is still closed; but the whole current

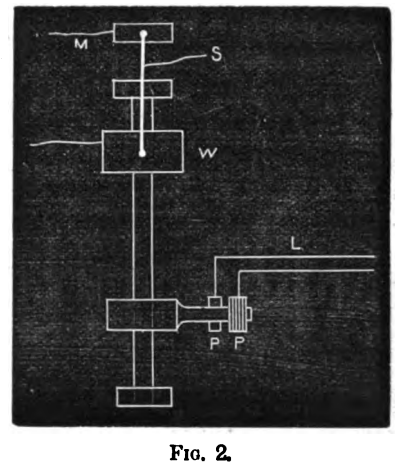

Fig. 2.

now traverses the subsidiary conductor, and the fuse at once melts. This fuse allows a weight to fall (*see* Fig. 2), where W is the weight and P P the switch, and thus instantly disconnects the whole circuit.

The practical form of cable to carry this into effect is shown at Fig. 3. A close-wound spiral of tinned copper wire, several wires being for preference arranged in parallel, is braided over,

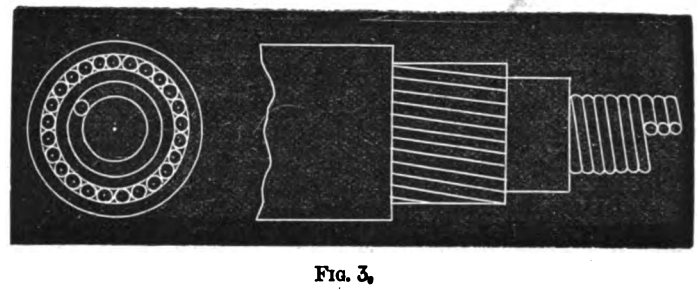

Fig. 3.

but not heavily insulated. Over this is laid a stranded conductor of the required area, and this in turn properly insulated in the usual manner. If the cable is torn down from the roof, or broken in any way in tension, this inner conductor extends to an indefinite extent, for as it gets drawn out the diameter of the spiral decreases, and hence it becomes quite loose in its tube. The outer conductor being broken, the spiral conductor carries the whole current for an instant till the fuse breaks,

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when the whole conductor is disconnected from the supply. Fig. 4 shows the cable thus broken and extended.

It sometimes, however, happens that a cable may be cut in two by a falling rock, or even by a sharp instrument like a knife or axe. By a small addition to the arrangements already provided, this also leads to an instant disconnection of the circuit before it finally breaks, and hence without spark at the point of rupture. Fig. 5 is arranged similar to Fig. 1, except that at the further end of the cable from the generator is a resistance, R, in the circuit of the subsidiary conductor. The effect of this

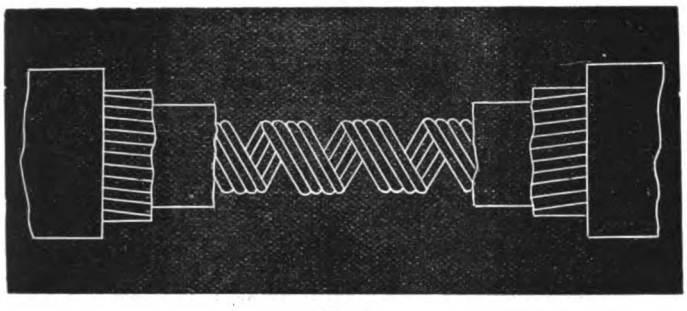

Fig. 4.

is that the ends of the cable being at the same potential, the fall of potential along the subsidiary conductor is less than along the main conductor, and that, therefore, a difference of potential exists between them. If, therefore, the cable is crushed by falling stone—or if the cable be cut by a metallic instrument effecting the same result—while the inner and outer conductors are in contact, there is an immediate increase of current in the subsidiary conductor, thus melting its fuse and disconnecting the cable as before. This cable, therefore, really acts by transferring the electrical rupture of the cable to some point, such as the switch-board at the top of the pit where it is unimportant, thus making its use safe under all circumstances.

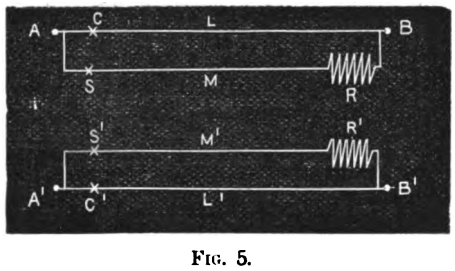

Fig. 5.

Apart from colliery work, the use of this cable would be desirable for overhead high-tension wires, as, if broken, the broken ends would not be left in the road with the current on, and thus would not be left a source of danger to persons and animals in the street.

INSTRUMENT MAKING FOR STUDENTS.—IV.

THE MIRROR GALVANOMETER.

There is, perhaps, no electrical instrument so useful, so delicate, and so accurate, as a good mirror galvanometer. It may be less convenient than other kinds as regards portability, but when once properly set up in a good position it can be used for a great variety of tests. The instrument now to be described, though, perhaps, not too beautiful from an instrument maker's point of view, is easily made, and is capable of a very fair degree of sensitiveness.

The instrument is built upon an L-shaped support of wood *a a'* (Figs. 1 & 2), mahogany being the best wood to use. The upright piece is 5¼in. high, and the horizontal base is 5in. long; both pieces are 4in. wide and ¾in. in thickness. The two pieces are held together by 2in. No. 10 round-headed brass screws *b b*, the heads of these screws and of a shorter screw, *b'*, of the same size form the legs on which the instrument rests, levelling screws being unnecessary. In the middle of the upright part of the stand there is a taper hole, 1¼in. in diameter at the front of the instrument, and $1\frac{5}{16}$in. at its small end. The centre of this hole should be 2⅛in. from the top. This taper hole is closed at the small end by a pane of glass, 1¼in. square, which is let in flush with the surface of the stand. A piece of thin brass tube, *d*, 1in. diameter outside and $2\frac{1}{16}$in. long, is mounted on a brass plate, *e e*, being fitted and soldered into a hole cut therein. The dimensions of the brass plate are $2\frac{1}{2} \times 1\frac{1}{2} \times \frac{1}{16}$; it is screwed on to the upright by means of the screws *f*, and coincides with the taper hole. This brass plate serves to keep the glass plate, *c*, in position. The screws, *f*, should be ½in. No. 8 countersunk brass screws. A second brass tube, *g*,

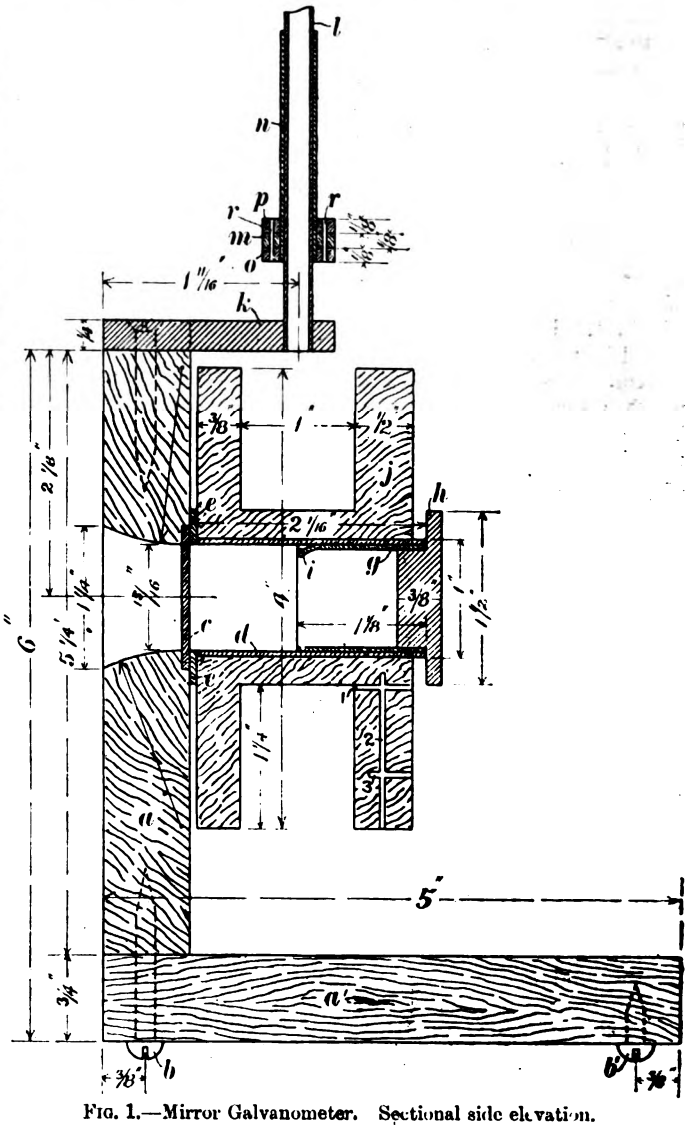

Fig. 1.—Mirror Galvanometer. Sectional side elevation.

slides smoothly (but not loosely) into *d*. It is 1⅛in. long, and one end is filled up by the brass plug *h*, which is soldered into it. This plug has a flange which should be milled. On the inner edge of the tube *g* are two saw cuts, ⅜in. deep and about $\frac{1}{16}$in. apart; the brass tongue formed between them is bent slightly inwards, as shown at *i*. The needle system is suspended from this tongue.

The bobbin, *j*, on which the coils are wound, is made of box wood, and is 4in. in diameter, and slides over the tube *d*; the front or inner flange is ⅜in. wide; the back flange, on which the terminals are fixed, is ½in. wide; and the space between, in which the wire is wound, is 1in. wide and 1¼in. deep. If the coil is to be of fine wire, the first layer should be of No. 22 S.W.G., the outer end of which is passed through the wood of the bobbin to the terminal, as follows:—First make a hook at the end of a piece of fine steel wire, and push it down to the bottom of hole No. 1 (Fig. 1) in the thick flange of *j*, then pass about 3in. of the No. 22 wire through hole No. 1, and pull

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it (by means of the steel wire hook) through hole 2 as far as the edge of the flange. Then (by means of the hook) again pull it through hole No. 3, which should be drilled close to the screw of the terminal. The outer end of the coil should be passed through a hole drilled close to the screw of the other terminal. These terminals are of the same sort as those on the two instruments last described (see *The Electrician*, June 26th, July 31st). They are tapped into the boxwood, and clamped by screwing down the lower nut on the outside. The screws should not, of course, pass quite through the wood. It will be seen that the instrument may have any number of coils of different resistances, &c., as long as the dimensions of the bobbin are as shown in the drawing.

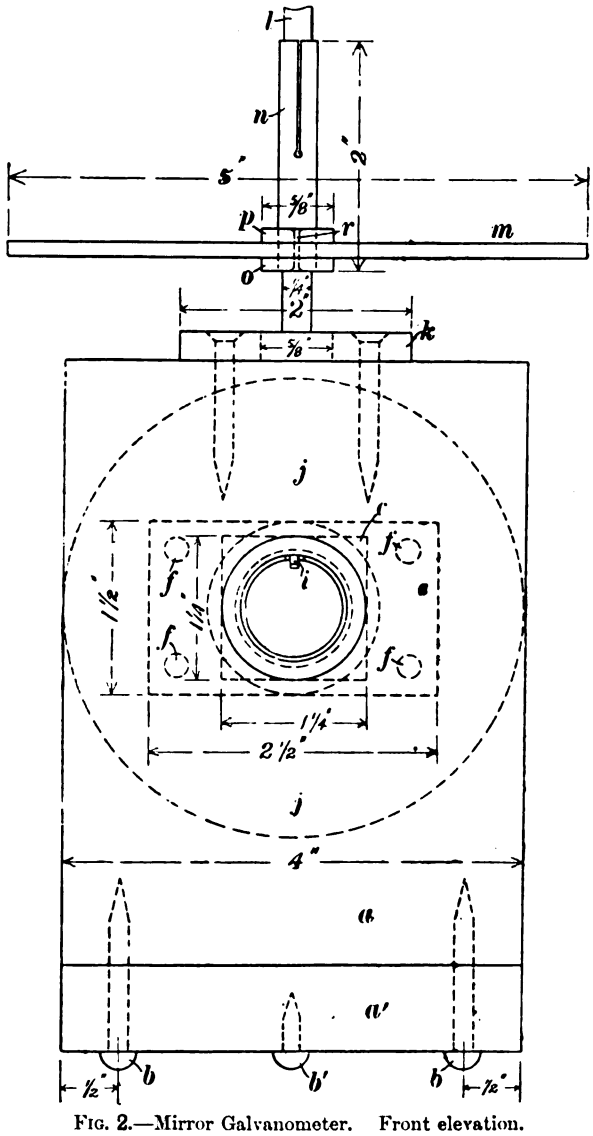

FIG. 2.—Mirror Galvanometer. Front elevation.

A T-shaped piece of brass, *k*, is screwed to the top of the upright, and at the end of the shank, with its centre exactly over the centre of the coil, is a hole into which a piece of brass tube, *l*, 7in. long and ¼in. in diameter, is soldered. This supports the directing magnet, *m*, which is mounted on a piece of tube, *n*, 2in. long, and of sufficiently large bore to slide easily upon *l*. Two brass washers, *o* and *p*, are ⅛in. thick and ⅝in. in diameter. The lower one, *o*, is soldered to the tube, *n*, and the magnet, *m*, and the upper washer, *p*, are slipped on, and the two washers and the magnet are fixed together by means of the rivets, *r*. The tube, *n* should have a narrow saw-cut an inch or so long on opposite sides of it, so that its ends may be slightly closed up, and thus grip the tube *l* in at any point in its length. Fig. 3 shows the needle system, which consists of a thin disc of mica or paper, *s*, having a diameter about $\frac{1}{32}$in. less than the inner bore of the tube *g*. From one edge a slot is cut to the centre, about ⅛in. wide, a short tongue, *t*, being left at the end of this slot, to which the suspending fibre is fastened. A small mirror, *u*, of silvered microscope glass is cemented on to one side of the mica disc, and on the other four bits of hardened and magnetised watch spring, about ¼in. long and $\frac{1}{16}$in. wide, are fastened, The corners of the mica disc must be cut

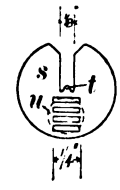

FIG. 3.—Mirror Galvanometer. Needle system.

away to allow the disc to swing freely past the tongue from which it is hung. One end of the suspending fibre is fastened to the tongue *t*, by means of sealing wax or shellac, and the other end is similarly fastened to the tongue *i* (Figs. 1 and 2)

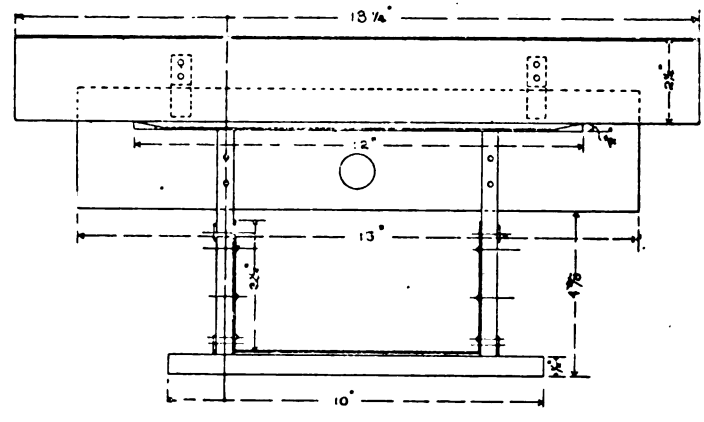

FIG. 4.—Mirror Galvanometer. Lampstand and Scale. Front elevation.

in such a manner that when the tube is held level, *i* being at the top of the vertical diameter, the disc *s* hangs exactly at its centre, and swings freely. The coil may then be placed on *d*, as shewn, and the tube *g* slid into position, the only

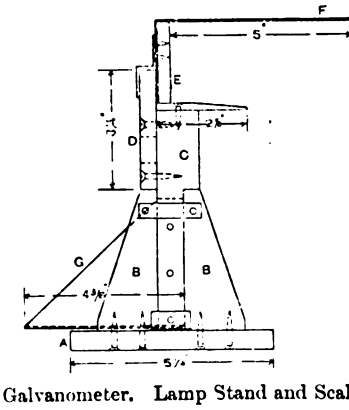

FIG. 5.—Mirror Galvanometer. Lamp Stand and Scale. End elevation.

levelling necessary being the turning of *g* round its axis until the needle system swings freely. Figs. 4 and 5 show respectively a front elevation, an end elevation, and a section of the lamp stand and scale.

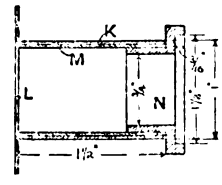

FIG. 6.—Mirror Galvanometer. Collimating Tube.

Upon a base board of mahogany A, 10in. by 5in. by 2½in., are fixed two pair of triangular uprights B B (Fig. 5), a space ¾in. wide being left between each pair in which move the two slides C C. These slides are joined at the back by the cross piece D, in the

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centre of which is fixed the collimating tube (shown in Fig. 6). The scale of the instrument, which may be divided into millimetres or any other convenient division, is drawn on paper and fixed to the scale board E. A tin screen F is fixed to the back of this scale board and extends about 5in. beyond it. This extension is bent over at right angles, and serves to shade the scale from light reflected from the walls and ceiling of the room; its under side should be painted a dead black. On the back of the scale board are also two lugs of brass, by means of which it is hung on to the cross piece D. Another screen, 2½in. wide and about 1ft. long, is placed across the top of the slides and serves to cut off light reflected upwards from the table upon which the apparatus is placed. Screwed to the inside of the slides is a tin stirrup G, on which the lamp is placed (a small paraffin lamp with a wide flat wick will be found sufficient). The slides are kept in position between the triangular uprights B B by cross pieces of brass screwed to their lower ends; they are further prevented from being pulled out from between these uprights by two other cross pieces fixed to the top of the latter. The lamp and scale, &c., may be raised or lowered until the spot of light from the mirror falls on the scale; the slides should be sufficiently friction tight to remain in this position of their own accord without further clamping. The collimating tube (Fig. 6) consists of a brass tube K, 1in. outside diameter, having at one end a flange (a rectangular flange is the more easily made). The tube K passes through a hole in the cross piece D, to the back of which the flange is screwed. Another tube M slides smoothly into the first. Both tubes should be about 1½in. long. At the outer end of the tube M, is a boxwood cell N, having a hole through its centre ¾in. in diameter, this hole terminates in front in a recess 1⅛in. in diameter and $\frac{3}{16}$in. deep, to be occupied by a lens of about 5½in. focal length, this may be cemented neatly into position with black sealing-wax, a piece of fine wire is placed across the cell in front of the lens. The cell N is fixed to the tube M by means of a couple of brass wire pins.

Should any trouble be caused by the vibrations of the room in which the galvanometer is set up (a most likely thing to happen), the instrument should be placed upon a three-legged wooden stand; this stand should be weighted with a heavy lead weight, and its feet should rest not directly on the floor, but upon cushions of india rubber ½in. thick. Unnecessary light upon the scale may be avoided by painting the walls near it a dead black or covering them with black calico.

THE FRANKFORT EXHIBITION.—X.

(FROM OUR SPECIAL CORRESPONDENT.)

The firm of Kummer and Co., of Dresden, have thought it worth while to exhibit rather extensively, and their exhibit should gain them a reputation in countries outside Germany. The particular branch of electric lighting to which they devote most attention is ship lighting, and they have carried out many navy contracts. They make both engines and dynamos. We give below some illustrations of the apparatus manufactured by this firm :—

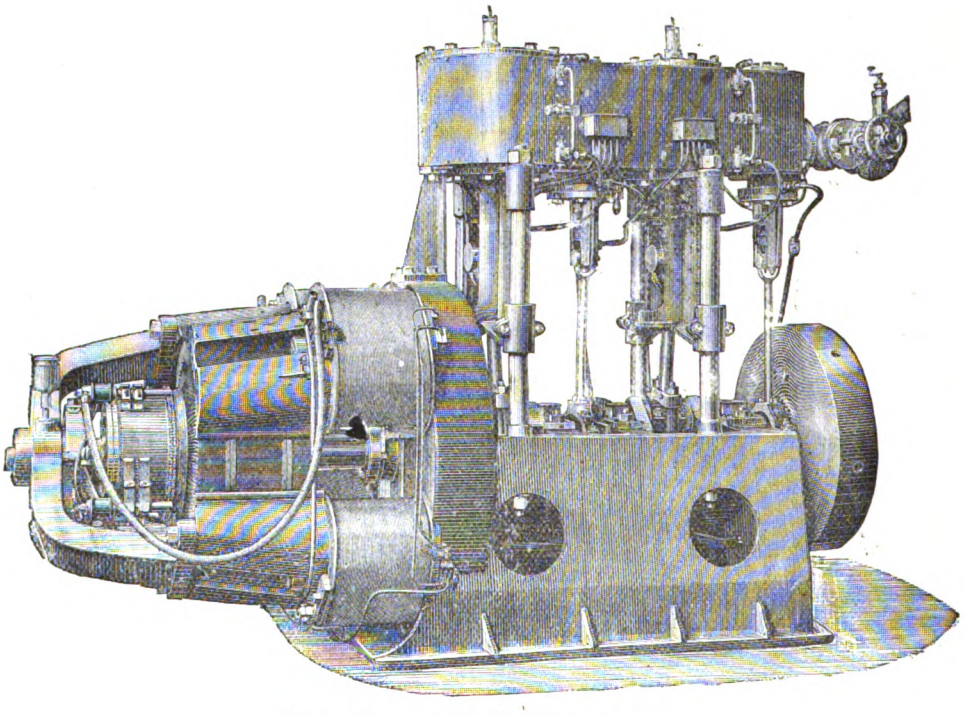

Fig. 1.—Kummer 54 H.P. Steam Dynamo.

Fig. 1 shows the largest machine they have at the Exhibition. It is intended to deliver 40 kilowatt when running at 450 revolutions, and is used chiefly for accumulator charging; it is one of the few compound machines used for this purpose at the Exhibition. The disadvantages of the dynamo seem to be its not very compact form, and the stray field which there must necessarily be when the magnets are arranged as shown. It has, however, found much favour on board ship. The magnets, and the frame supporting them, are cast in one piece with the bed plate of the engine, and the armature spindle is simply a continuation of the engine shaft. The dynamo has a good broad collector with its strips rather wide, and there is no perceptible sparking. The diameters of the high and low pressure cylinders of the compound engine used to drive the dynamo are respectively of 9½ and 15 inches. The piston stroke is a little more than 8¾ inches.

The latest type of dynamo turned out by this firm is shown in Figs. 2 and 3. It is a very compact and solidly built machine, and one likely to stand wear and tear. At a speed of 775 revolutions, one of these machines will give 13·4 kilowatts. A compound wound machine of this type is running as a motor in the Machinery Hall.

To provide for cases in which it is desired to prevent the possibility of more than one dynamo being switched on to one circuit, Messrs. Kummer and Co. manufacture a practical apparatus, of which the illustration Fig. 4 gives an idea.

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It consists of a number of vertical and horizontal brass strips mounted on a stout wooden base. The three horizontal brass pieces shown in the illustration are joined up to the + poles of the three dynamos with which this particular apparatus is used in the Exhibition, while the vertical cross pieces are joined each with the positive end of one of the circuits to be fed. Both the horizontal and the vertical conductors have holes bored in them in such a way that any vertical conductor can be joined, by means of a special key, with any of the horizontal conductors. To prevent the possibility of the bar being connected with another horizontal conductor, a sliding piece is arranged on the top of it, provided with holes in such a manner that when the connecting key is once introduced to join the bar with one of the horizontal conductors all the other holes are barred.

The contact key is cylindrical at the lower and conical at the upper end. The cylindrical part is cut down the middle parallel to the axis, and a hole is bored right through the key.

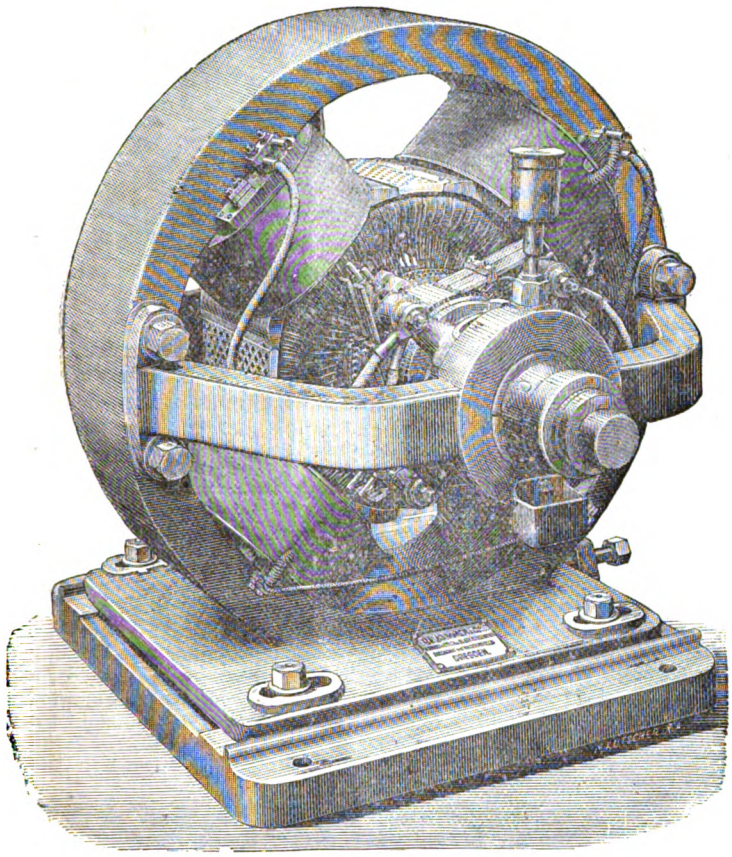

FIG. 2.—Kummer Four-Pole 19 H.P. Dynamo.

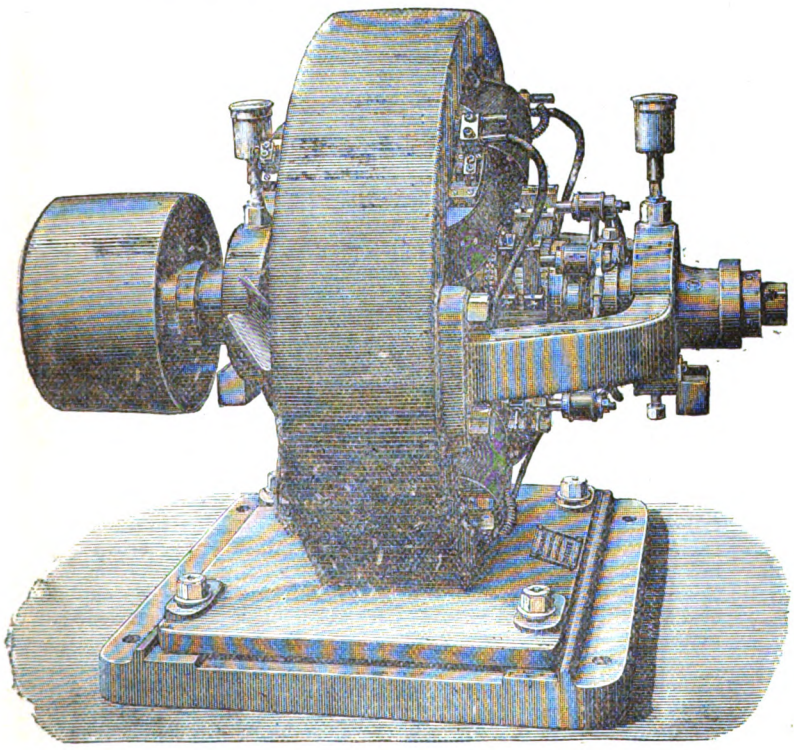

FIG. 3.—Kummer Four-Pole 19 H.P. Dynamo.

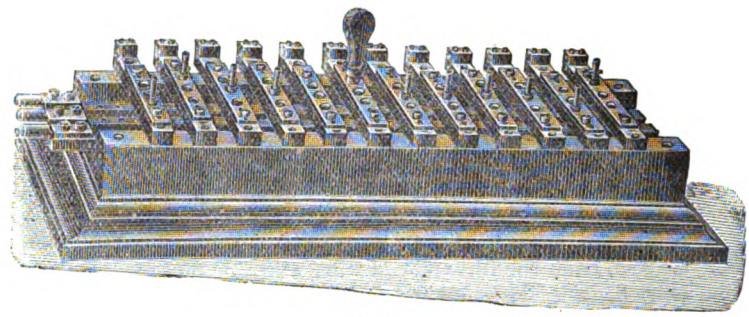

FIG. 4.

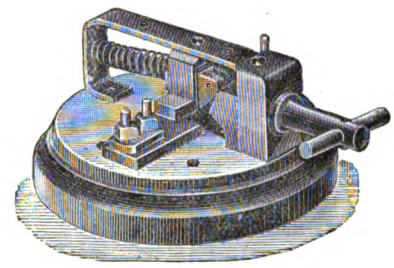

FIG. 5.

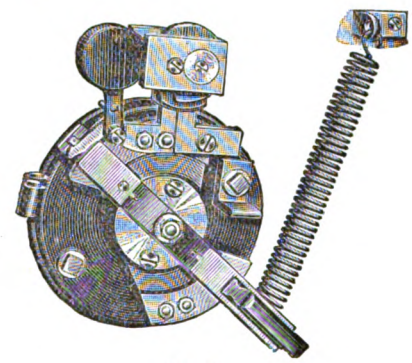

FIG. 6.

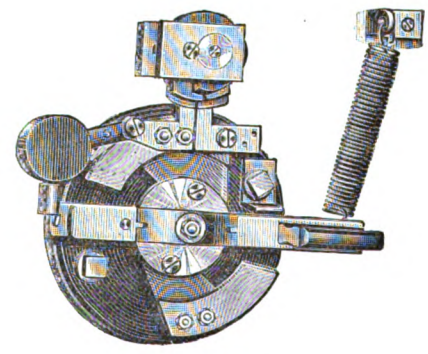

FIG. 7.

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The boring runs upwards to a pointed cone, with a screw-thread cut in it, into which fits a corresponding conical screw piece, at the top of which is the key handle, which fits on as in the case of an ordinary tap with removable key. To make contact the sliding bar is lifted and the key inserted, a turn to the left makes good contact with the vertical piece, and a turn to the right screws up the interior conical screw, thus pressing out the two divided parts of the lower part of the key, and forming a good contact with the lower or horizontal conductor.

Each of the circuits is provided with an instantaneous cut-out switch, such as is shown in Fig. 5. The "make" and "brake" are very rapid.

An automatic cut-out made by Messrs. Kummer and Co. is shown in Figs. 6 and 7. The base is of cast iron, and two insulated contact pieces are arranged on opposite sides of it, the connection being made by a cross rod moveable round the pivot. As seen from the illustration, when the apparatus is in circuit (Fig. 6), a spring tends to break the circuit and snap the lower part of the cross lever upwards. This is, however, prevented by a catch held in position by the iron clapper. To regulate the action of this clapper, and ensure its falling and liberating the cross lever when the current has reached the prescribed value, the following method is employed:—The upper terminal is lengthened out into a spiral with three turns, and provided with pole pieces, thus making an electro-magnet, arranged in such a way that its attraction just fails to keep up the iron clapper when the current reaches the prescribed value below which it is decided not to go.

THE ARCAS SYSTEM OF ELECTRO-PLATING.

Existing methods of covering corrodible metals with a protective coating leave much to be desired. Two reasons may be assigned for this: the first, that the adhesion of the protective film is imperfect; the second, that the film itself is attackable to some extent. Gold properly deposited electrolytically forms a fairly satisfactory coating, but its cost is against it; platinum until lately could not be deposited in a bright coherent state, and the success claimed for a process much discussed some little time ago was far from complete; more recently still investigations by an American chemist have led to a more rational method being devised, and the practicability of the process may be now safely conceded. At the best, however, platinum is unlikely to find a very extended application as a protective coating. Its price and its porosity are serious obstacles to its use for many purposes. The former limitation forces itself upon the notice of the least observant, but the latter is too often overlooked by those who might reasonably be expected to realise its importance. When it is remembered that it has been proved that zinc oxide may be reduced by the gases penetrating a platinum crucible heated by a gas flame, and that in the best analytical practice a porcelain tube is preferred to platinum in the determination of carbon in steel, in spite of the obvious convenience of the latter and its adoption by some chemists of repute, it will be understood that a mere film, such as all plating from the nature of the case inevitably is, cannot be expected to protect the surface to which it is applied effectively, and unless it be effective it might as well be abandoned altogether.

There remain, therefore, silver and nickel. The former adheres well to most metals, and is not porous; the latter adheres badly to iron and steel, for which it is, perhaps, most largely used, and fails to protect them adequately; a glance at the "bright parts" of a modern cycle, after a few months' wear, will confirm this statement.

In view of these facts it can readily be understood that there is a considerable field for a method of plating which shall be non-porous, not readily tarnishable, and moderately cheap. The London Metallurgical Company claim to have introduced a process of the kind, which was recently inspected by a representative of ours. The coating deposited is an alloy of silver, but it is noticeable that the great tendency of that metal to become black by the formation of sulphide of silver from contact with the sulphurous gases present in a town atmosphere is not possessed by the alloy. The new method, which is known as "Arcas" plating, costs about the same as ordinary electro-plating, and is applicable to all the purposes for which silver and nickel are now used. On account of the foreign patents for the process being still incomplete, we cannot yet publish details of the anodes and electrolyte used, and the methods of deposition. Testimonials from numerous users go to show that the plating has unusual powers of resisting atmospheric influences, articles protected by its means showing almost no deterioration after prolonged exposure. The claims made for the possession by the alloy of the qualities mentioned above will, of course, have to be made good by independent expert testimony, upon the production of which it may be conceded that a distinct addition to our manufacturing resources has been made.

THE TRANSMISSION OF SIGNALS ON UNDERGROUND CABLES.*

In a Paper read by Herr A. Franke before the Elektrotechnischer Verein (Berlin) there is some interesting information as to the way in which an electric current is propagated on underground cables, &c. These cables possess both electrostatic capacity and self-induction; and knowing the values of these two quantities, we could attack some of the problems by mathematics, but it is better to have recourse to direct experiment. In this abstract we shall not occupy ourselves with the manner in which the experiments were carried out, but only with the results obtained. The principle employed was that of a Morse key, connected either to a circuit possessing a given capacity and self-induction, or to a cable.† The method allowed of the measurement of the current at exceedingly brief intervals of time. These intervals were brief enough to enable one to estimate the one-ten thousandth of a second.

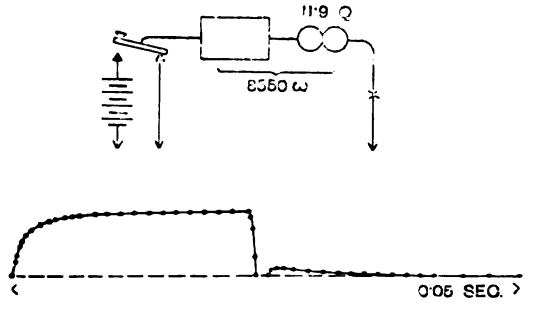

FIG. 1.—Resistance and Self-induction.

In Fig. 1 we have a circuit of a total resistance of 8,550 ohms, and self-induction 11·9 quadrants. The curve is that which is obtained when the battery is connected to it, and when this connection is broken. The time included between the arrows is the total duration of the phenomenon. The initial curve is an exponential curve, the exponent being the ratio of the resistance to the coefficient of self-induction. The curve obtained deviates a little from the theoretical curve. It rises more rapidly, bends over more decidedly, and approaches its final value more slowly than theory would indicate. When the battery circuit is broken the current falls to zero in ·0004 second, the conductor circuit was closed through the back-stop ·005 second later; the current at first rose slightly, and then fell slowly to zero. This current could only be due to the induction of the electro-magnet, which shows that the magnetism does not disappear at the same time as the current, which phenomenon is undoubtedly caused by undulatory currents, and these explain also why the exponential curve does not coincide with that deduced mathematically.

The curves in Fig. 2 refer to a case where there was only resistance and capacity and no self-induction. The conductor consisted of two rheostats, the resistances of which were respectively 1,710 and 6,840 ohms, the capacity being one microfarad. Curve I., showing the growth of the current, is an exponential one, as in the previous case, the exponent now being the ratio of the resistance to the capacity. This curve agrees exactly with the theoretical curve. When there is no capacity the current is everywhere the same, while here there is a difference between the current behind (Curve I.) and that in front of the condenser (Curve II.). At the first instant the condenser absorbs an appreciable quantity of electricity, and

* From *La Lumière Electrique*.

† For description of apparatus, see *The Electrician*, Vol. XXVI., p. 459.

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the potential falls to zero. The initial value of the current in front of the condenser only depends on the resistance which there may be in front of it; it is greater than that of the steady current. The current falls according to an exponential, and attains its steady value at the same time as the current on the far side of the condenser. As soon as contact is made with the backstop, the condenser suddenly discharges. The two currents (I. and II.) approach zero, taking an exponential curve.

When it is a case of a circuit possessing both capacity and self-induction, we see that these two properties act in opposition. We obtain under certain circumstances electric oscillations, the duration of which depends on the square root of the product of these two values. Oscillations of this kind were frequently observed, and their duration varied between wide limits. The curve in Fig. 3 shows the result obtained by discharging a 1 microfarad condenser through the

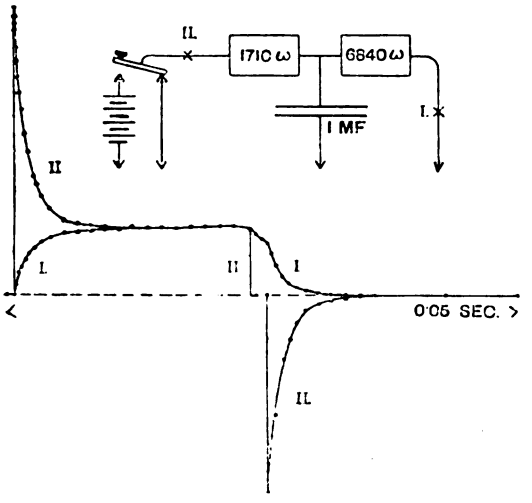

Fig. 2.—Resistance and Capacity.

coils of the electro-magnets of a Morse instrument. The resistance was 563 ohms, the self-induction 11·9 quadrants, the duration of the oscillation ·025 second. It is to be seen clearly by the figure that the curve cuts the axis five times.

Under favourable conditions one can obtain oscillations on charging a condenser. To show this the large resistance of 18,900 ohms was interposed between the key and the condenser (see Fig. 4), a resistance of 750 ohms, equal to that of the battery, being connected to the back stop. In order to reproduce as closely as possible the same conditions on charge and discharge, means were taken to avoid breaking the circuit on passing from one stop to the other. It was then observed that the current passed its normal value, oscillated about it, and disappeared in the same oscillatory manner. The slight differences between the theoretical curve and the experimental curve are again due to the magnetism of the iron.

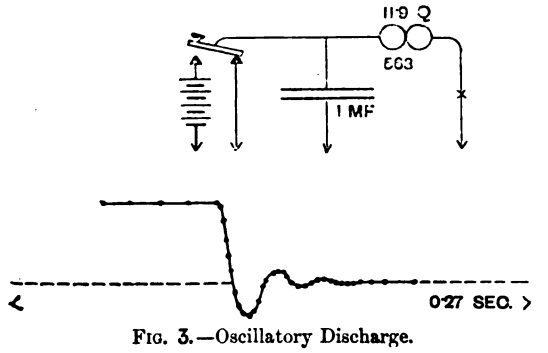

Fig. 3.—Oscillatory Discharge.

The conditions become more complicated when it is a question of telegraph circuits, where the capacity is spread along the whole length of the line instead of being concentrated at a given point, and where the current varies from one point to another. Self-induction and the insulation of the line come in, and instead of obtaining simple easily calculable curves we then obtain complicated curves. Nevertheless, it is easy to see that these curves should agree in certain characteristic features with those already considered. It is evident that measurements on these sort of circuits cannot be so accurately carried out as on artificial lines. The induction of neighbouring wires especially may have a considerable disturbing effect. The curve in Fig. 5 relates to the cable connecting Berlin to Perleberg, 276 kilometres long. To avoid as much as possible the effects of induction the two ends of an artificial cable were added, which brought up the total length to about 500 kilometres. The total capacity of the conductor was 112 microfarads, the total resistance 3,800 ohms.

Fig. 4.—Oscillatory Charge and Discharge.

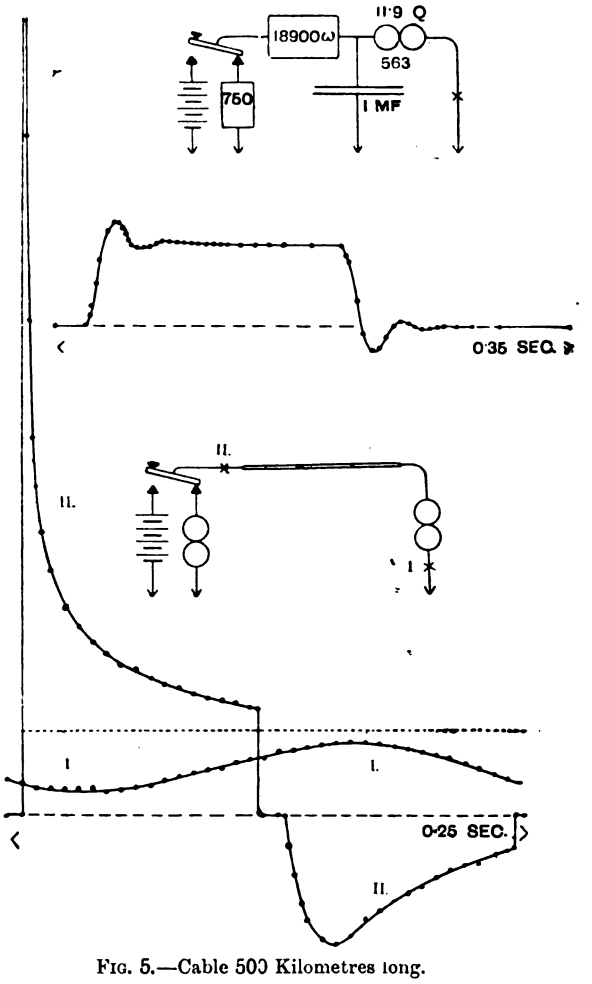

Fig. 5.—Cable 500 Kilometres long.

The current at the near end of the line denoted by Curve II. exhibits a high initial value, reduced by one half in the figure. The first point observed was also the highest, showing that the current reached its maximum value in less than ·0001 second. This value

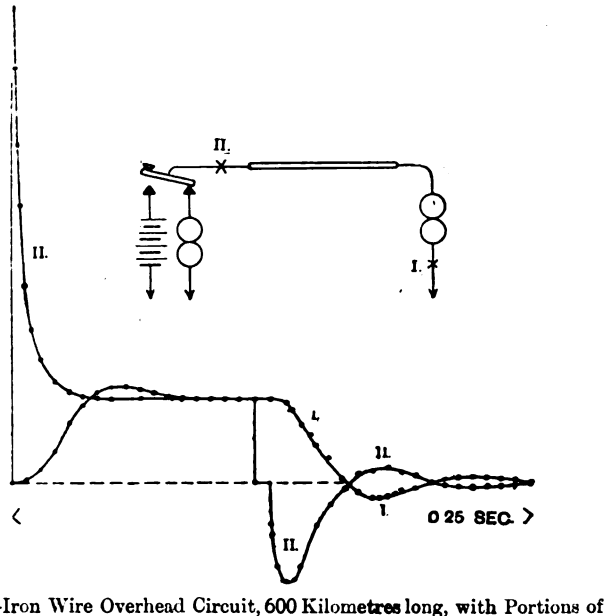

Fig. 6.—Iron Wire Overhead Circuit, 600 Kilometres long, with Portions of Cable.

is fifteen times that of the steady current indicated in the figure by a dotted line. This shows that there was considerable capacity behind the key, and that the initial value of the current only depends on the battery resistance. We thus see how important it is to use low

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resistance batteries in cable work. The charging wave diminishes first quickly, then more slowly, and at the end of one-eighth of a second the steady value is still not attained. The curve next shows the breaking of the battery circuit, and then the discharge through the back stop. Here there is no peak, because the self-induction of the Morse apparatus opposed any sudden increase of current. The current at the far end of the line vanishes sinusoidally (Curve I.), and never attains either the stationary value or zero. It is to be observed that this wave only attains its maximum value long after contact has been made with the back stop.

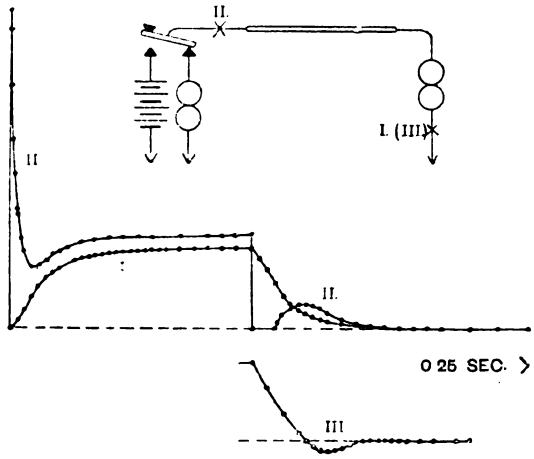

FIG. 7.—600 Kilometres of Overhead Bronze Wire.

The curve in Fig. 6 was taken on an overhead line running from Berlin to Hanover and back, a distance of 600 kilometres. The conductor was of iron wire, but in the towns there were cables which brought up the capacity to 11 microfarads, the resistance being 7,500 ohms. As at the beginning of the line there were a few kilometres of cable, the top of the curve is, as was previously the case, very high. On the diagram only a portion of this initial period is shown. The charge is, however, quickly terminated, and curve II. (Fig. 6) soon attains a steady value. We have here to do

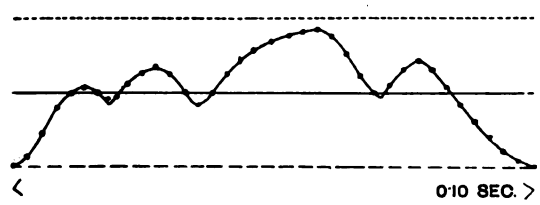

FIG. 8.—Bronze Conductor : 600 *f's* per minute.

with a high resistance circuit, at the end of which, close to the Morse apparatus, are a few kilometres of cable ; and these, as we have pointed out above, are the necessary conditions for obtaining an oscillatory *charge* at the far end of the conductor. Curve I. (Fig. 6), in fact, exhibits these oscillations. The oscillatory discharge which is observable on either side of the condenser, is symmetrical ; it is strongly damped, the duration of the oscillation being ·083 second.

It was not possible to investigate an iron overhead line of any length, since in every town there are portions of cable ; but long

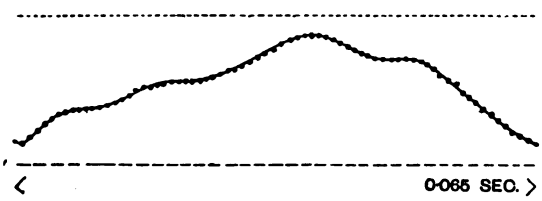

FIG. 9.—Bronze Conductor : 924 *f's* per minute.

overhead lines were obtained by utilising bronze wire telephone circuits. Tests were carried out on a line running from Berlin to Hamburg and back. This line was 600 kilometres long, but its resistance was only 1,700 ohms, and its capacity about 2 microfarads ; it was impossible, owing to external influences, to obtain the exact value of the capacity. In spite, however, of this low capacity, spread over the entire length of the line, we see (Fig. 7) that the point corresponding to the charge is still fairly high. When the line is charged, which in this case is soon completed, no more electricity can be pumped in at one end than flows away at the other (as is seen by Curve I.) ; and as, owing to the self-induction of the receiving apparatus, the steady value is not yet attained, the current at the near end at first falls below its steady value, after which the two curves (I. and II.) rise together. The constant difference between Curves I. and II. is due to a defect in the insulation of the line. On lifting the key the conductor discharges fairly rapidly (see Curve I.), and on closing on the back-stop there is no oscillation (Curve II.). The current at the extreme end of the line disappears in the manner depicted in Curve III., from which we see that when the key is midway between the stops it is possible to obtain an oscillatory discharge even with aerial conductors.

These curves show that when dealing with cables self-induction is negligible compared with capacity ; that in the case of a mixed circuit, consisting principally of aerial conductors, self-induction gives rise to oscillations ; but that its influence is most marked in the case of purely aerial conductors.

It may now be asked what happens when, instead of a single current, it is a question of several currents quickly following one another, such, for instance, as telegraphic signals ; the conductor then remains more or less charged. To investigate the matter, a rapid succession of *f's* (— — — —) was sent to line, and the current at the distant end was analysed.

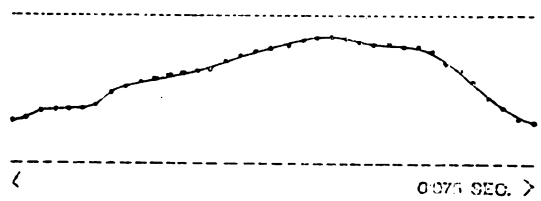

FIG. 10.—Mixed Circuit : 800 *f's* per minute.

At the highest possible speed attainable by hand (60 to 80 *f's* per minute) each signal arrived individually at the receiving end. It was only when a speed of 600 a minute was attained that curves such as those shown in Fig. 8 were recorded. Under these conditions we neither get the steady value of the current, nor a complete discharge, but only maxima and minima. But this does not (with a suitable apparatus available) prevent the interpretation of the signals received. The phenomenon, well known to telegraphists, of the shortening of the first dot of a signal is very observable.

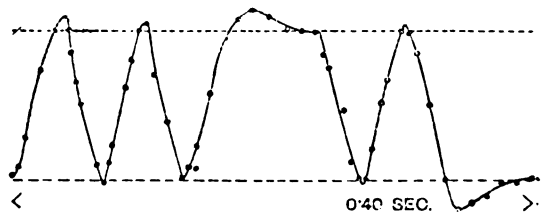

FIG. 11.—Mixed Circuit : 150 *f's* per minute.

Under these conditions, and for the lines in question, the above is the limiting speed of transmission. If the speed is still further increased and attains 924 *f's* per minute, the curve, Fig. 9, is obtained, in which it is no longer possible to distinguish the dots. It would be impossible to communicate telegraphically under these conditions.

With iron conductors and pieces of cable the unfavourable curve shown in Fig. 10 is obtained at only 800 *f's* per minute. The disturbing influence of high resistance and capacity is plainly discernible.

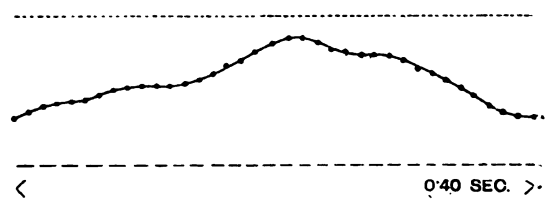

FIG. 12.—Cable : 150 *f's* per minute.

Curve Fig. 11 refers to a mixed circuit, and shows that with 150 *f's* per minute transmission is still perfect. The current it will be observed rises at times above its steady value. So long as it is not a question of high speed transmission, cabled conductors at the extremities of a circuit are rather advantageous than otherwise.

M. Jacquin * has shown mathematically that a condenser and a resistance introduced behind the receiving apparatus act favourably

* *La Lumière Électrique*, Vol. XXXIV. p. 32.

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on the transmission; but that the capacity of the conductor and the self-induction of the receiving apparatus also produce this result is a fact which has not hitherto been pointed out.

It is found on comparing the results obtained on cables, that with speeds for which overhead conductors give perfect transmission, a curve, such as that in Fig. 12, is obtained, which no longer permits one to distinguish the signals—a fact which demonstrates in a striking manner the superiority of overhead circuits. To lessen this defect, M. Godfroy* has proposed to put at the beginning of the conductor and behind the key an inductive coil connected to earth. Curve, Fig. 13, shows the result of doing so. The signals are much clearer.

For similar conductors possessing resistance and capacity the current curves become the same when the speed of the signals is inversely proportional to the product of the resistance into the capacity. This fact has often been made use of in connection with mixed circuits. The preceding curves show what degree of accuracy is attained by this law.

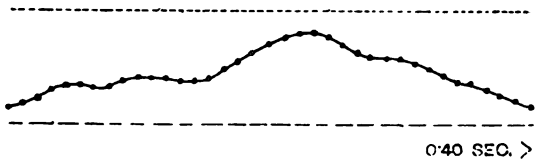

Fig. 13.—Cable: provided with the Godfroy device; 150 *f's* per minute.

The following table gives, in the third column, the values of $K \times R$ for the different conductors, K being in farads and R in ohms. The fourth column gives the speed of signalling v, and the fifth column the product of these two quantities. It is to be observed that the product in question is sensibly the same for cables and mixed circuits. For bronze wire circuits it would be necessary to increase the speed of transmission in the ratio of 1 to 16 to obtain the same product. If this product were the only thing one had to concern oneself with, the same current curve could be obtained with 15,000 *f's* per minute. But with a bronze conductor, self-induction intervenes in a preponderating manner. The last column gives the value of $\frac{L}{R}$ for the different conductors, and would give the current curves if there were no capacity. As it is not easy to measure the self-induction of long conductors, and as it is only a question here of giving a general idea of the phenomenon, the self-induction of the apparatus, 12 quadrants, has alone been taken into account.

Table.

Conductor.	R	K	KR	v	KRv	$\frac{L}{R}$
Cable	4,800	112×10^{-6}	·54	150	8·1	·0025
Mixed circuit	8,500	11×10^{-6}	·093	800	7·5	·0014
Bronze wire...	2,600	2×10^{-6}	·0052	934	4·8	·0046

The deductions that we may draw from these investigations is that for mixed circuits the speed of transmission depends on the product of resistance and capacity, but only on the condition that self induction by resistance is negligible in comparison to this product.

TANNING BY THE AID OF ELECTRICITY.†

BY DR. S. RIDEAL AND A. P. TROTTER.

(*Continued from page 507.*)

At present it is customary to judge of the quality of the leather from its appearance and colour; a hide is, however, frequently struck through when it has only absorbed a comparatively small quantity of tannin, and the colour of the finished leather varies considerably with the kind of tanning materials employed.

lish the qualitative fact that the combined action of the motion and the electric current considerably hastened the rate of tannage. It was of interest, however, to ascertain, if possible, what was the average rate obtained when the hides were slowly rotated in the pit and when no current was passed through the liquor.

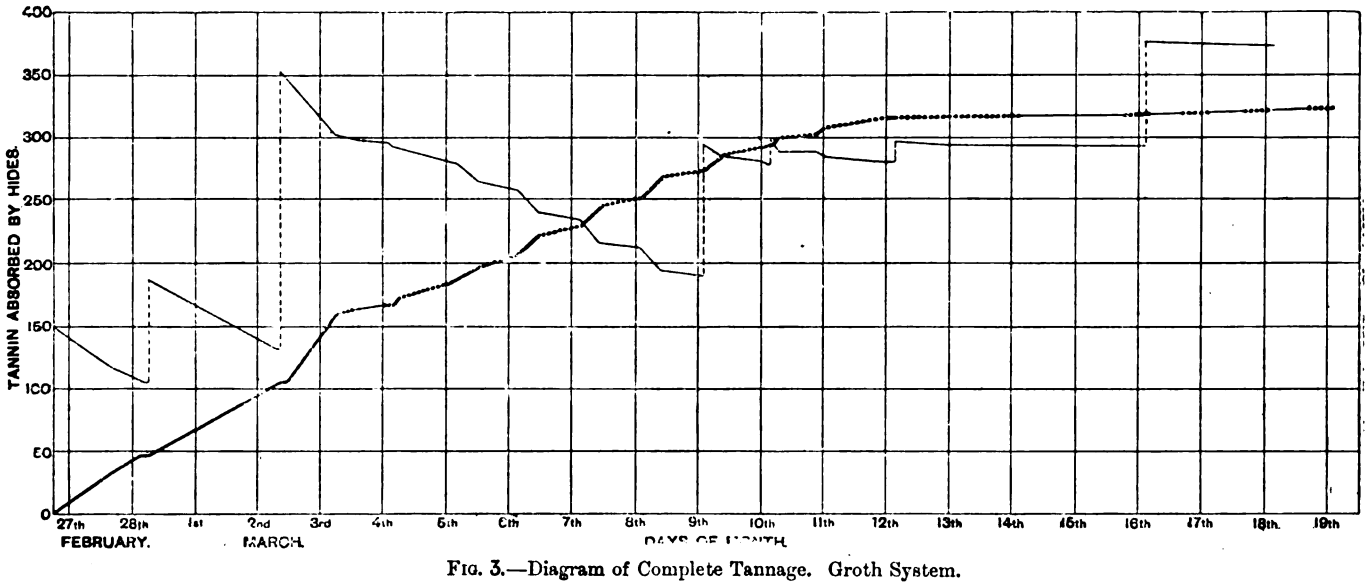

Fig. 3.—Diagram of Complete Tannage. Groth System.

Rest ——— Motion ..... Motion and Electricity ———

In Fig. 3 the daily absorption of tannin from the liquor in the above experimental tannage by this process is shown, in which it will be seen that the rate of absorption, as already shown in Table III., gradually diminishes as the hide becomes saturated with the tannin, and finally the rate becomes so small that the ordinary permanganate valuation of the liquor is useless for estimating the change.

In Fig. 4 the daily readings for a similar experiment are plotted out and show analogous results. The readings were, however, discontinued on the eleventh day, although the quantity of tannin absorbed by the hides used in this experiment was not sufficient to completely tan them. They were subsequently finished in another vat. From the foregoing results, we have sufficient data to estab-

A comparative experiment was made to establish this point, the results of which are given in the accompanying diagram (Fig. 5). Two circular vats were employed, A and B, containing 1,600 and 2,400 gallons of liquor respectively, made up to approximately the same strength. A batch of hides which had previously been limed, unhaired, and fleshed under the same conditions, was divided into two portions, whose weights were in the ratio of the volumes of the liquor in the two vats, so that the loss of tannin per unit volume of the liquor is equal to the absorption of tannin per unit weight of hide in each vat. The liquor in both vats was analysed at the commencement of the experiment (Feb. 14th, 4 p.m.), and the hides remained suspended in the liquor, without any motion or electric current being applied to them, for 44 hours. Samples of the two liquors were analysed, and the rate of absorption in each vat deduced and found, as might be expected, to be practically

* See *The Electrician*, July 17, p. 303.

† From the *Journal* of the Society of Chemical Industry, No. 5, Vol. X.

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identical. The subsequent treatment of the hides in the two vats was so arranged that the hides in vat 1 should be subject to the joint influence of motion and electric current, whilst those in vat 2 were under the influence of motion alone. The experiment was then repeated for a longer time, and after an interval of rest the conditions were reversed, the hides in vat 1 being subjected to motion alone, and those in vat 2 to the joint action of motion and electric current.

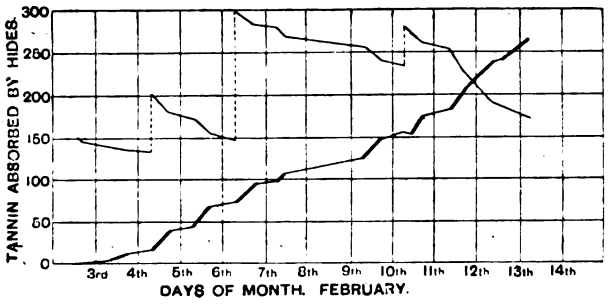

FIG. 4.—Diagram of Complete Tannage.

Rest —— – Motion and Electricity ——

The results are plotted together in Fig. 5, where the upper curves show the gradual loss of tannin from the liquor and the lower curves calculated from them, to show the quantity absorbed by the hides (as during these experiments the liquors were not strengthened, the lower curves are the images of the upper). From the slope of the lines the relative rates can be obtained.

The following table summarises the above results ;—

Comparison of the Rates of Tanning.

Kind of tanning.	Total loss in parts per 10,000.	Total time in hours.	Rate.
Ordinary tannage	12·8	88	·145
Rest after motion and electric current	15·3	56	·273
Rest after motion alone	15·7	56	·280
Motion after electric current	8·6	24	·36
Motion alone	18·8	38	·49
Motion and electric current	53·6	38	1·42
Electric current after motion	59	24	2·47

Thus, while the initial rate in vat 1 was ·163 parts per 10,000 per hour, and ·104 parts per 10,000 per hour in vat 2, when a current of electricity and motion was applied to vat 1, and motion only to vat 2, the rate of loss in vat 1 rose to 2·43 parts per 10,000, and in

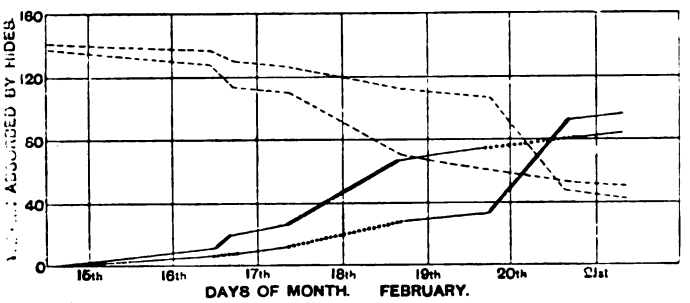

FIG. 5.—Diagram of Comparative Tannages.

Loss of tannin from liquor - ····· Motion ·····

Rest – – – Electricity and motion ——

vat 2 to ·63 parts per 10,000. After an interval of rest, vat 1 showed a rate of 1·36 parts per 10,000, and vat 2 a rate of ·52 parts per 10,000. It is to be noted, however, that the apparent falling off in the rate in vat 1 may be due not only to the gradual diminution as the tanning proceeds as already referred to, but to the electric current during the night of this experiment being smaller than during the day, or possibly interrupted for some time, as no electrician was controlling the experiment during the night in question. After an interval of rest the conditions were reversed, motion being alone used in vat 1, and motion and a current of electricity simultaneously in vat 2. The rates of loss were then found to be ·36 parts per 10,000 per hour in vat 1 and 2·46 parts per 10,000 per hour in vat 2, thus confirming the previous figures and proving that the vats or proportions of liquor and hide employed in each were not affecting the comparison.

The average values thus obtained are in the proportion of—

Ordinary tanning.	With motion.	With motion and electricity.
·133	·503	2·08

or the rate of tanning under the combined influence of electricity and motion is four times faster than the rate when motion alone is employed, and 16 times faster than when neither are used.

We have not tried the effect of a current of electricity on the hides when at rest, although no doubt the tanning rate would be similar to that obtained when motion is employed, as the hides when at rest would not be uniformly influenced by the flow of the current through the vat, and the leather produced would therefore be unequally tanned. It ought also to be noticed that these rates were obtained with the motion of the kind produced by the first kind of machine, and that no doubt other rates of tanning would be observed under the influence of other kinds of motion, and if no provisions were adopted for preventing the hides from being in contact with another, it is safe to assume that the rate would be considerably less, as the circulation of the liquor to every part of the hide would be prevented.

Theoretical Conclusions.—The original suggestion of Grothius in 1805, with its chain of molecules and bonds, its pairing and unpairing, formed a very fair working hypothesis, and has been gradually developed and elaborated until we are to-day confronted with a very serious complication of theories. Helmholtz has suggested that there is no tearing apart of the molecules, but that work must be done in separating an atom from its electrical charge, or in removing electricity from an atom of high specific attraction, and giving it to another lower in the scale. Clausius considered that the molecules are always changing partners, that dissociation, in fact, is always present to some extent, and that the effect of the electromotive force is to give direction to movements which are already going on. Arrhenius considers that dissociation is complete in very dilute solutions, but Traube maintains that such a view upsets our conceptions of chemical affinity, and makes the convenient assumptions as to the nascent state impossible, and flatly contradicts the theory of hydration. The idea of a nascent state has been to a large extent given up by chemists, but the ions undoubtedly are occasionally liberated in a form in which, although they do not readily combine with the other matters in solution, and are in a self-combined state, *e.g.*, ozone, they are in a very energetic condition. From *à priori* considerations, as we have observed, this nascent state or the resulting facilities for combination which arise from the cause whatever it is called, might be expected to facilitate the operation of tanning in the same way that it affects the operations of bleaching and treatment of sewage. But although the tannins are molecules of some complexity there are no grounds for supposing that dissociated molecules react with the gelatin of the hides, and we have no proof whatever that any such dissociation takes place in the tanning process. Turning to the question of dialysis and osmosis, we find dialysis to be a form of diffusion to which electrolysis has been compared by Wiedmann, who showed that the conductivity of an electrolyte may be considered as depending on the coefficient of diffusion of the components through each other. Dialysis is a selective diffusion, and is undoubtedly facilitated by the passage of an electric current, and it is easy to see that such an action must be extremely advantageous in the slow process of tanning, which is probably retarded enormously by the superficial coagulation which takes place almost at the moment of first contact of the green hide with the tanning liquor.

Theories of dialysis are at present incomplete, but Van t'Hoff's law of osmotic pressure and our knowledge of the migration of ions indicate the direction from which a satisfactory theory of the process may be looked for.

In the meantime, the facts which have been established are of a very different order, so widely different indeed that hypotheses of osmosis and observations of the migration of ions are alike useless. Dr. Oliver Lodge's experiments with dilute H_2SO_4 give a velocity of about $\frac{1}{35}$cm. per sec. for H, and $\frac{1}{800}$cm. per sec. for SO_4. With jelly and a slope of potential of 1 volt per cm. the velocity of Ba was $\frac{1}{3000}$cm. per sec, and Cl and Br $\frac{1}{4150}$cm. per sec. But with a slope of one-tenth of this, *i.e.*, about 1 volt. per cm., the rate of progress of tanning is only about ·025cm. in 100 hours, or $\frac{1}{13000000}$ cm. per sec., or $7\frac{1}{2}$ inches per annum.

It thus seems necessary to attribute part of the hastening effect to the direct action of the electric current upon the suspended hide.

Helmholtz and Ostwald have given considerable attention to the resistance of electrolytes, and it is pointed out that the degree of dissociation can be determined from the conductivity. Arrhenius concludes that the resistance is greater as the ions are more complex, and the tannin molecules are considerably more complex

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than any compounds that have yet formed the subject of careful experimental work. Not only have we a complex solution, but it is admitted that with weak currents secondary actions are likely to take place at the electrodes, and it is only with strong currents that the real ions are liberated. The fact that the rate of absorption of tannin distinctly diminishes with even four amperes shows that if any chemical action be involved it is probably some secondary action of considerable complexity, and that, therefore, there is no need for attempting to explain the process by an electrolytic breaking down of the tannin molecules.

Although it is difficult to advance any definite theory as to the effect of the passage of the electrieal current upon the process of tanning, the increased rate is obviously due to the current hastening the chemical union between the bodies which are in a condition to combine. It is well known that chemical combinations which only take place at elevated temperatures, can be induced to occur at ordinary temperatures, when an alternating current is passed through the mixture of the two bodies. Amines combine with aldehydes in this way, and Meritens (Eng. Pat. 16,947, 1889) has proposed to bring about etherification, and so effect the quick ageing of spirits by the help of an alternating current.

Dr. S. Ehrmann, of Vienna, has also recently shown that a moist skin absorbs salts very rapidly from their solution when an electric current passes, and Wagner has also proposed to administer cocaine by a similar process of cataphoric medication. In Ehrmann's experiments, in which a current of 10—20 milliamperes was passed from zinc electrodes through a solution of methylene blue, in two cups in which the hands of the observer are immersed, blue spots appeared on the back of the hand in the anode vessel and none on the other hand in the other vessel. The absorption was most marked where the hair and fatty glands are situated, and thus throws light on the fact that in tanning the process is most rapid on those parts of the skin, and that the electric current has no doubt a distending effect upon the pores of the skin, as indicated by our earlier experiments. Lithium chloride is similarly absorbed by endosmosis through the skin, and Edison has shown that gouty secretions in the fingers are speedily dissipated by the prolonged action of currents of 20 milliamperes. H. N. Lawrence and Dr. Harries have obtained similar results (Soc. Arts, March 11, 1891). We believe that the hastening of the tanning process is of a similar character, and we draw attention to these experiments as analogous, if not confirmatory of the explanation of the process which we tentatively advance in this Paper.

We have to thank Mr. Bawden, one of our assistants, and Mr. Fox Bourne for help in carrying out part of the experimental work of this Paper.

THE LONDON TELEPHONE SERVICE.

The following letter, which appeared in *The Times* of Tuesday, will be read with interest :—

TO THE EDITOR OF THE TIMES.

SIR,—Having for some years been much interested in telephonic matters, and having devoted not a little time to the consideration of the subject, may I be permitted to say a few words in reply to Mr. Faithfull Begg's letter and in support of the Duke of Marlborough's contentions ?

Mr. Begg would apparently have us believe that the present inefficient condition of telephony in this country is due almost entirely to obstruction on the part of the Post Office, and that the costliness of telephonic communication in the metropolis, though to some extent due to past mismanagement, is for the greater part unavoidable. He apparently admits that the two-wire system is preferable, but defends the existing single-wire arrangement by declaring that without powers to build subways no other is possible.

With reference to this latter question, I venture to dispute his assumption. There may be difficulties in working the double-wire system above ground, but that these are by no means insuperable is evidenced by the Post Office exchange at Cardiff and by the Mutual exchange at Manchester, in both of which the double-wire system is exclusively employed, and where overhead wires are also used.

But to come to the most important question of all—namely, that of cost—Mr. Begg seems entirely to deny the Duke of Marlborough's statement that London can be telephoned with a £10 subscription at a profit. It appears to me that this assertion of the Duke of Marlborough's is demonstrable from the accounts of the National Telephone Company itself, but to show this I must be pardoned if I have for a few moments to touch on the past history of London telephony.

When about two years ago an amalgamation took place of the various telephone companies, the existing National Company bought up the business of the United Telephone Company, which up to that date had run all the metropolitan telephone exchanges. The capital of the latter company prior to the amalgamation stood at some £500,000, about one half of which sum represented the expenditure on plant, the remainder having been paid away chiefly for patents. These patents, or, at any rate, all of them that are of importance, have now expired, so that, assuming that the money expended on plant was well laid out, about £250,000 is the present value of what the National Company purchased.

For this, however, they paid no less than £1,250,000. It is this latter figure that stands as the value of the London exchange system in the existing companies' books, and it is this latter figure that requires a £20 rate of subscription in order that a dividend may be earned.

If we retain the £250,000, which is the most that can be taken as representing the value of the plant, and write off the remaining £1,000,000, which now represents nothing at all, and with which a new company would not be burdened, let us see what is the result.

The National Company have at present some 6,000 subscribers to their London exchanges, which, at the existing rental of £20, gives a yearly gross revenue of £120,000. The Company's last dividend was at the rate of 7 per cent. per annum, so that this £120,000 is apparently sufficient to cover all working and other expenses, and to pay a dividend at the above rate on the £1,250,000 capital. Reduce this capital, as mentioned above, by writing off the £1,000,000 that represents nothing, and a rental of £8. 6s. 8d., producing a revenue of £50,000 per annum, would still pay all expenses and give 7 per cent. on the £250,000 that may be taken as the cost of the plant.

Mr. Begg says that the Directors of the National Telephone Company would be glad to know how London could be telephoned at a remunerative profit with a £10 rental. If he means a remunerative profit on an inflated capital like that of the National Telephone Company, the feat is impossible; but that it can be done by a new company, starting fair, and spending its money judiciously, is, I think, proved by the above figures, taken from the published accounts of the National Telephone Company itself.—I am, Sir, your obedient servant, A. A. CAMPBELL SWINTON.

66, Victoria-street, Westminster, September 5th.

SCANDINAVIAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

COPENHAGEN, *September* 7, 1891.

In Stockholm, the works in connection with the new central station are rapidly progressing, and the laying down of the electric light cables and the telephone cables of the State telegraphs is being simultaneously proceeded with, both being encased in underground concrete covering. The former have an aggregate length of 45 kilometres, with a sectional area of 260 millimetres for the main lines and 16·25 in the branch lines. The system is constructed for 10,000 simultaneously-burning lamps. The larger cables consist of a number of copper wires, placed in the centre, round which is the insulation, then a lead jacket, then more insulation, and, outside all, an iron sheath protected by asphalt or some similar substance. The cables are laid in the ground without any further protection. The work is being carried out by Siemens and Halske, of Berlin. In another part of the town the firm of Messrs. Crompton and Co. is installing an experimental main, 385 metres long, on their well-known air-insulation principle.

The Copenhagen central station is also approaching completion ; the brickwork is practically ready, and the six boilers, three Babcock and Wilcox and three Steinmüllers, are in place. The engines, which have been delivered by the Burmeister and Wain Shipbuilding and Engineering Company, Copenhagen, are also being delivered. The cables in the streets are mostly laid, and the house work is also well in hand. The site round the buildings will be dug out to a depth of 10ft., and the accumulators will be placed there. The dynamos from Siemens and Halske are ready, and only wait for the installation of the engines.

CORRESPONDENCE.

THE LONDON TELEPHONE SERVICE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR,—In reply to your letter to me of September 1st requesting further information on the subject of my letter to *The Times* of August 20th, I have much pleasure in sending you the following information. The Company which is about to commence its operations by offering the telephone to everybody in London on the twin-wire system and with the Mann exchanges is the "New Telephone Company (Limited)." This Company was formed in 1884 by several gentlemen interested in bringing about an efficient telephone service in London. The Company obtained a licence from the then Postmaster-General similar in every way to previous licences. They proposed, however, to use a telephone which it was believed would not infringe patents owned by others. In this belief the New Telephone Company was mistaken and the Directors found themselves unable to continue the business of the Company during the existence of patents held by the United Telephone Company (Limited), and they therefore determined to place the Company in liquidation. However, the patents in question having expired it was resolved to take the Company out of liquidation, and the debts of the concern having been paid in full this was accordingly done. A strong Board is in process of formation, and

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the Solicitors to the Company have been instructed to apply to Parliament next Session for powers to run underground mains where necessary, so as to enable the telephoning of large towns such as London, &c., to be established on the plan of central and sub-exchanges upon the lines indicated by Mr. Bennett in his Cardiff Paper. In order to telephone a town such as London, the first step is to divide its entire area into sub-stations. These sub-stations are to be connected direct with subscribers, say 500 to 1,000 at each sub-exchange. From these sub-exchanges to the central exchanges it is sufficient to run a much smaller number of trunks, say 25 or 50, according to the business done on this sub-exchange. In the City we should require many. In Kensington very few mains, not more than a few subscribers ever wishing to speak at one time. Now, the whole of this system, both of central and sub-exchange, will be on twin wires, and the exchanges will be on the Mann system, so that there will be no delays in getting switched on to anyone throughout the whole of the 23 square miles of the London district. £10 a year will be the terms of subscription for talking all over this area.

The New Telephone Company are not only going to begin in London, but they intend to commence operations in other large towns of England on the same plan, with the object of connecting all these towns up with one another, and thus establish long lines of through communication right through England, on the twin-wire plan. For a £10 a year subscription you will be able to do all your business and perform your social engagements by conversation from your own writing tables, with a little pegging through connection in your clerk's office or in your basement to the exchange, so that you will not be worried by the telephone bell, but will only admit your being at home if you choose. You will have through communication with other towns, your country places, your friends who live in those country towns, and if you happen to be out of doors and wish to communicate with anyone, your own house for instance, you will find call stations all over London where you will go in and call up who you like for a small fee.

It is now six years ago since I set up nearly sixty telephones about this house and property. I have two central exchanges interconnected, and I talk all over the place from any room to anywhere habitually. A small ten-year old boy runs the basement exchange of 48 different ways, and I may say that the telephone is hardly ever out of use during the day. This system is twin wire, and I therefore knew long ago what the advantage implied. The electric light mains which run alongside these twins have no effect whatever on the instruments. I placed all these facts before Mr. Brand when he was Chairman of the United Telephone Company, which I believe has amalgamated with another Company, the National, that still continues its business on a single-wire plan, with only two central exchanges for the 23 square miles area of London, the terms of subscription being either £20 or £16 a year, according as you consent to tie yourself up with a term of years agreement. Now, in order to establish a twin-wire system you have got to divide your area into squares like a chess-board and commence in each of these areas at the same time. The central stations for London that will be connected with these sub-stations by other mains would be from three to five for all London. The system is fully set forth in Mr. Bennett's paper. The National Telephone Company, in order to arrive at such a system as the New Telephone Company are going to inaugurate, will have to make very extensive changes, which would practically mean a total reorganisation of their whole system. In fact, Mr. Bennett said at Cardiff that it would be practically impossible for them to convert their present system without putting in entirely new plant.

Now, the only thing that renders this healthy competition possible is the expiry of the great telephone patents, which have been worked with a draconian severity against inoffensive persons beyond any experience of former patents. This is now all over, and anyone may put a telephone in his house to-day without anxiety, either for his amusement or to replace bells and speaking tubes, or what not. What we may not do, however, is "start a business of letting out telephones for intercommunication, and taking rent for same." This would be infringing the Postmaster's rights, and this can only be done therefore by companies or persons who hold a right from the Postmaster to do this. Now the New Telephone Company have one of these admirable "All England licences," of which there exist very few. They have about 20 years unexpired on this licence, quite time enough to build up a very fine industry. The amalgamated Telephone Companies, which call themselves "The National," have a capital of about three millions sterling. What the Government would have had to pay for exercising the purchase clause with regard to this three million of stock no one at the General Post Office had the very smallest idea! With our present experience, however, a capital of this amount is not necessary to telephone the whole country; and Mr. Bennett's estimate of from twenty to thirty pounds per head expenditure for every subscriber added, on a twin-wire plan of sub and central exchange, is probably about the proper cost of erection, including everything. Maintenance is a considerable item, but I am confident from very careful investigation of the business, that at £10 a year per subscriber a very handsome profit can be earned for the shareholders. The New Telephone Company will, therefore, take its fresh start after having been freed from its past difficulties, under most promising auspices. Every penny of capital that will be subscribed will go to the erection of twin wire plant and modern exchanges, which are the result of all the laborious experience which has been earned by precursors in this field, and which the New Telephone Company was unabie to make use of till this year. The cost of putting down this system is perfectly well known to our Electricians, and we shall commence to secure sub-exchange stations and erect exchange centres all over London very shortly. Our wish is, however, before we go to the cost of swinging these hideous large trunk connections across streets and negotiating the way-leaves, to bring the whole matter of underground connections once more before Parliament in the telephone interest. Another encouraging feature in the enterprise is that the telephone has hardly taken any start in London outside the City. I find it quite impossible to communicate ever between the City and West End. This will give the New Telephone Company great advantages. It is impossible to develope a telephone system so as to extend it to all residents in a town unless the central and sub-exchange is first carefully devised, as the fixing of these exchanges stereotypes the system for good. The New Telephone Company will have no difficulty in this respect, as the present overhead system that exists depends on two isolated exchanges at Cannon-street and Regent-street. The new telephone system will not interfere with the existing system, but will take its radiation points at situations which have no bearing on the National plant. Whether the present amalgamated companies will approve of the strong competition we are about to put them to I do not know. They have three millions sterling of capital on which they have to pay dividend. The value of their patents is gone, and it would seem that the whole of their overhead system will have to be re-devised from end to end. The New Telephone Company will therefore have this advantage, that it has not got to carry this gigantic dead-weight of capital, and that it will probably be able to reduce its price far below what the existing Company can, and that it also will be able to develop with extreme rapidity so soon as it commences its operations in earnest. I have no doubt whatever that this New Telephone Company must grow to be one of the most important concerns of this country, little inferior to the Government telegraph in its development, in the course of the next few years.

If anyone who has occupied himself with electrical science will think out, not only what the telephone does, but the number of uses and substitutions for other purposes that the telephone is fitted for, he will perceive that his almost unstudied instrument is a greater invention than the telegraph itself, and that the day will come when Morse codes and Wheatstone transmitters will be superseded, and that the human voice will either be its own record for telegraphic purposes in the future, or some form of recorder of the sound waves will be constructed, such as the phonograph, which will provide a written record of those electrical waves produced by

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the human voice. The telegraph instrument will then be as antiquated a machine, in England, anyway, as the older semaphore, and the New Telephone Company will have reaped its harvest by having placed itself in the van of this development.—I am, Sir, &c., MARLBOROUGH.

Blenheim Palace, September 7, 1891.

SUBMULTIPLES OF THE OHM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR,—With regard to the means at the disposal of Prof. V. Jones for determining the value of small resistances, and Mr. Preece's remarks upon the same, mentioned amongst "Notes" in your last issue, permit me to state that Messrs. Crompton and Co. have made and supplied such submultiples of the ohm for the measurement of heavy currents for several years past.—I am, Sir, &c., WM. C. FISHER.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

RESULTS OF TENDERS.—The following is the list of tenders received for lighting the new Ladywell Sanatorium, Salford, by electricity, for which Messrs. Maxwell and Tuke and E. and F. Hewitt are joint architects :—

R. A. Scott	£2,543
Siemens Bros. and Co.	2,200
C. Mellier	2,167
Fowler, Lancaster, and Co.	2,125
J. C. Howell	2,100
Drake and Gorham	2,080
Anderson and Munro	2,034
Sharp and Kent	1,975
W. Leake	1,912
Paterson and Cooper	1,900
General Electric Power and Traction Company	1,847
Swinburne and Co.	1,841
E. Scott and Mountain	1,790
City Electric Light Company	1,765
Barclay and Sons	1,665
Charlesworth, Hall, and Co.	1,655
India Rubber, Gutta Percha, & Telegraph Works Company	1,640
Roper's Engineering Company	1,640
Holmes and Co.	1,630
Mather and Platt	1,627
Edmundsons (Limited)	1,591
Electric Installation and Maintenance Company	1,575
C. A. Parsons and Co.	1,570
West End Electric Company	1,546
Gülcher (New) Electric Light and Power Company	1,535
J. D. F. Andrews and Co.	1,516
J. Pearce	1,450
Mercier, Corlett, and Co.	1,445
Brush Electrical Engineering Company	1,431
General Electric Company	1,425
H. A. Clegg	1,368
R. and H. Dobson	1,352
Alterion Company (Limited)	1,345
C. E. B. Pritchett	1,320
Manchester Edison-Swan Company (with extra powerful dynamo) (accepted)	1,312
W. Rowbottom and Co.	1,020

MORRIS BROTHERS (LIMITED).—This firm have just brought out a combined ammeter and voltmeter, which is mainly intended to measure the electromotive force and current of batteries, but may be used for other purposes, such as measuring the E.M.F. and the amount of current passing through accumulators while charging or discharging the amount of current taken or used by an incandescent lamp or lamps, &c. Each instrument is calibrated separately; they are well made and will stand rough usage.

MESSRS. HUGHES AND HILL.—Mr. Edgar Hughes and Mr. Claude W. Hill have commenced the business of consulting electrical engineers, under the above title, at 5, Parsonage, Manchester, and are prepared to advise on all kinds of electrical installations.

ELECTRICAL POWER STORAGE COMPANY (LIMITED).—We have received a very neatly got up catalogue giving particulars and prices of this Company's various types of accumulator, cell-tester, automatic apparatus, &c.

MESSRS. W. H. WILLCOX AND CO.—This firm, who about two years ago purchased the goodwill of W. Goodwin and Co., leather band makers, Primrose-street, Bishopsgate, and have since carried on the business there under the old name, notify that the works are now removed to 34 and 36, Southwark-street, London, S.E., where the business will in future be carried on under their own name.

RAILWAY ELECTRICAL CONTRACTORS (LIMITED).—A meeting of the shareholders of this Company (in voluntary liquidation) will be held at the offices, 1 and 2, Great Winchester-street, E.C., on October 23, at 3 p.m., to receive an account of the winding up.

DISSOLUTION OF PARTNERSHIP.—Messrs. J. Adams and Co., electric light engineers, of 37, Kensington High-street, have dissolved partnership.

SALE BY AUCTION.—Messrs. J. M. Klenck and Co. announce in our advertisement columns that they will sell by auction, at the Mart, Tokenhouse yard, E.C., on Thursday next, the 17th inst., the goodwill, plant, machinery, &c., of the electrical business carried on by Messrs. D. Judson and Sons (Limited), at the Atlas Works, Ewer-street, Southwark-street.

NEW COMPANIES, STATUTORY RETURNS, &c.

ALEX. WILSON AND COMPANY (LIMITED).—This Company was registered on September 4, 1891, with a capital of £20,000, in £1 shares, by Ashurst, Morris, Crisp and Co., 17, Throgmorton Avenue, E.C. The objects are :—To carry into effect an agreement with A. Wilson, and to carry on the business of mechanical, electrical, metallurgical and chemical engineers, manufacturers and contractors. The number of directors is not to be less than two nor more than five. Qualification, £100. Remuneration, £300 per annum, divided between them.

CULLINGWORTH GAS COMPANY (LIMITED).—This Company was registered on September 1, 1891, with a capital of £10,000, in £5 shares, by Waterlow Brothers and Layton (Limited), Birchin-lane, E.C. The objects are :—To acquire and carry on the Gas Works at Cullingworth, Yorks, now belonging to the Hallas Gas Company (Limited). To carry on at Cullingworth and elsewhere in Yorkshire the business of an electric light company, including that of electricians, mechanical engineers, suppliers of electricity for light, heat, motive power, or otherwise, and manufacturers of and dealers in all apparatus required for the generation, distribution, supply, accumulation and employment of electricity. Not less than two nor more than seven directors will be appointed. Qualification, £250. Remuneration as the Board shall determine. Solicitors: Taylor, Jeffery and Jessop, Bradford.

DOBSON AND BARLOW (LIMITED).—This Company was registered on September 1, 1891, with a capital of £750,000, in £10 shares, by Woodcock, Ryland, and Parker, 15, Bloomsbury-square, W.C. The objects are :—To acquire the business of engineers and machinists now being carried on by T. H. Rushton and B. A. Dobson, under the style of "Dobson and Barlow." To enter into and carry into effect an agreement with the above-named for the purpose. To carry on the business of ironfounders, mechanical engineers, machinery manufacturers, machinists, spindlemakers, millwrights, toolmakers, brassfounders, electro-platers, galvanizers, &c. To acquire, construct, control, and work (*inter alia*) electric works, gas and waterworks. T. H. Rushton and B. A. Dobson are the first governing directors. Qualification, £1,000. Remuneration of ordinary Directors £100 per annum each, that of governing directors £800 per annum each.

FIBRATE SYNDICATE (LIMITED).—This Company was registered on September 7, 1891, with a capital of £15,000, divided 12,500 ordinary shares of £1 each and 500 founders' shares of £5 each, by Jacobs and Weldon, 16, St. Helen's-place, E.C. It purposes to adopt and carry into effect an agreement dated July 22, 1891, between J. R. Thame of the one part and J. W. Taylor (for the Company) of the other part, for the sale to the Company of an invention of improvements in the manufacture of electrical insulating materials, and an invention of improvements in the manufacture of seamless tubes or conduits for electrical and other purposes, and to use, exercise and develop the said invention. The number of directors is not to be less than three nor more than seven. Qualification Remuneration not less than £250 per annum divided, amongst them.

HEATH'S (LIMITED).—This Company was registered on September 2, 1891, with a capital of £50,000, in £10 shares, by Dunn and Duncan, 87, Chancery-lane. The objects are :—To acquire and carry out a system of displaying advertisements invented by Henry Heath, and to carry on the business of advertising agents, printers, iron and brass founders, electricians, mechanical, chemical and electrical engineers, &c. The number of directors is not to be less than three nor more than seven. Qualification, £250. Solicitor : R. Okell, Manchester.

R. S. NEWALL AND SON (LIMITED).—This Company was registered on September 5, 1891, with a capital of £50,000, in £10 shares, by Waterlow Brothers and Layton (Limited), Birchin-lane. The objects are :—To acquire and carry on the business of manufacturers of wire rope, electric and telegraph cables, suspension bridges, and aerial and cable tramways, and of wire drawers, mechanical and electrical engineers, carried on by the firm of R. S. Newall and Son at Washington, Durham. The number of directors is not to be less than three nor more than seven, the first being F. F. Sheppel, F. S. Newall, and C. J. Banks. Qualification, the holding of £500 in shares.

WELLINGTON ESTATES COMPANY (LIMITED).—This Company was registered on September 4, 1891, with a capital of £5,000, in £10 shares by E. Lee Michell, Wellington, Somerset. The objects are :—To purchase

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develop, and turn to account land and house property of all descriptions; to acquire, construct, maintain and work roadways, tramways, electric power, heat, and light supply works, telephone works, &c. The regulations of Table A mainly apply.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the past week were £5,279.

CITY AND SOUTH LONDON RAILWAY COMPANY.—The traffic receipts of this Company for the week ended September 6, 1891, amounted to £672.

COMMERCIAL CABLE COMPANY.—This Company announces the payment on the 1st prox. of the usual quarterly dividend, at the rate of 7 per cent. per annum.

DIRECT SPANISH TELEGRAPH COMPANY.—The traffic receipts of this Company for the month of August, 1891, amounted to £1,631, as against £2,076 in the corresponding period of last year, or a decrease of £445.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of this Company are as follows:—Receipts in August, 1891, £23,600; 1st January to 31st August, 1891, £189,400; corresponding months, 1890, £181,000; corresponding months, 1889, £178,200.

INTERNATIONAL OKONITE COMPANY (LIMITED).—The first ordinary general meeting of the shareholders will be held at the Cannon-street Hotel, on Friday, October 9th, at 12 noon. The transfer books will be closed from the 23rd to the 30th inst.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The traffic receipts of this Company for the month ended August 31st were £3,050.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended September 4th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brasilian Telegraph Company, were £3,565.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The receipts of this Company for the month of August were £4,062, as compared with £5,013 in the corresponding period last year.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, September 2.	Price Wednesday, Sept. 9.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Sept. 9. Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
£1,300,980	Stock	12/0	Anglo-American	47 48	47½ 48½	5 11 4	Jan., Apr., July, Oct.	48½	47½
£2,849,510	Stock	24/0	Do. Preferred	86 87	86½ 87½	6 5 9	" "	87¼	86
£2,849,510	Stock	5/0	Do. Deferred	12¾ 13¼	12¾ 13¼	..	..	14	12¾
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99 102	99 102	3 18 5	January and July ..	..	..
130,000	£10	5/0	Brazilian Submarine	11¾ 12½	11¾ 12½	6 18 9	Mar., June, Oct., Dec.	12⅛	11⅞
£69,200	£100	5%	Do. 5 per Cent. Bonds	99 102	99 102	4 18 0	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107	103 107	4 13 6	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	107 109	107 109	6 3 10	April and October ..	110½	109¾
16,000	10	8/0	Cuba Submarine	10 11	10 11	7 5 6	February and August	..	..
6,000	10	10%	Do. Preference 10%	16½ 17½	16½ 17½	5 14 3	" "	..	..
12 931	5	3/2½	Direct Spanish (£4 paid)	3¾ 4¼	3¾ 4	7 0 0	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9½ 10½	9½ 10½	4 15 3	" "	..	..
60,710	20	3/6	Direct United States	11 11½	10⅞ 11⅛	6 5 10	Jan., Apr., July, Oct.	11 3/16	11
400,000	10	5/6	Eastern	14⅜ 14⅝	14⅜ 14⅝	4 8 10	" "	14⅝	14⅜
70,000	10	6%	Do. 6 per Cent. Preference	15 15½	15 15½	3 17 5	" "	15⅝	15 1/16
£1,200,000	Stock	6%	Do. 4 per Cent. Mort. Debenture Stock	107 110	107 110	3 12 9	May and November	109	107¾
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	107 110	4 10 11	February & August	108	107½
250,000	10	2/6	Eastern Extension	15 15½	14⅞ 15½	4 12 7	Jan., Apr., July, Oct.	15 3/16	15
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock	105 108	105 108	3 14 1	February & August	105½	..
£85,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	104 107	104 107	4 13 6	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	102 105	102 105	4 15 3	" "	104	..
180,227	10	4/6	Globe Telegraph and Trust	9⅜ 10	9⅝ 9⅞	5 6 4	Jan., Apr., July, Oct.	9⅞	9⅝
180,042	10	6%	Do. 6 per Cent. Preference	14⅞ 15½	14⅞ 15½	3 19 4	" "	15½	14⅞
150,000	10	5/0	Great Northern	18¾ 19¼	18½ 19	4 9 6	Jan., April, and July	18¾	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883 xd	104 107	104 107	4 13 6	March & September	..	..
17,000	25	37/6	Indo-European	41 43	41 43	5 15 3	May and November	..	..
38,348	10	5/0	London latino-Brazilian	6½ 7½	6½ 7½	6 0 0	" "	..	..
£100,000	100	6%	Do 6 per Cent. Debentures xd	104 107	104 107	5 12 2	March & September	..	..
9,000	8	4/0	Reuter's	8 8½	8 8½	4 14 1	April and October..	..	..
3,381	£100 Cert.	£1	Submarine Cables Trust 6%	117 121	120 125	4 16 0	" "	122½	..
15,609	10	6/0	West African Telegraph	8 9	8 9	5 11 1	January and July ..	..	..
£231,400	100	5%	Do. 5 per Cent. Debentures xd	95 98	96 99	5 1 0	March & September	97½	96½
30,000	10	2/0	West Coast o America	3½ 3¾	3½ 3¾	..	January and July ..	3¾	..
£150,000	100	8%	Do. Debentures 8% 1902	97 102	97 102	7 16 10	June and December	99	..
88,321	10	9d.	West India and Panama	1⅝ 1⅞	1⅞ 2	..	..	2	1⅝
34,563	10	6%	Do. 6 per Cent. 1st Preference	10 10½	9¾ 10¼	5 17 1	May and November	10¼	10⅛
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8½ 9¼	8 9	6 13 4	" "	..	..
61,683	15	9/0	Western and Brazilian	10¾ 11¼	10¾ 11¼	6 13 4	" "	..	..
30,364	7½	1/6	Do 5 per Cent. Cumulative Preferred	6½ 7	6½ 7	5 7 3	—	..	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	4¼ 4¾	4¼ 4¾	..	..	4 11/16	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	102 105	102 105	5 14 3	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	102 105	102 105	5 14 3	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	117 122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, per Cent. Sterling Bonds xd	98 102	98 102	5 17 8	March & September	..	..
			TELEPHONES.						
224,850	14/0	0/5¼	Consolidated Telephone Const. & Maintenance	⅜ ½	⅜ ½	..	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid)	7/16 9/16	7/16 9/16	6 3 11	Yearly	..	..
438,984	5	3/6	National	4⅜ 4¾	4⅜ 4¾	6 3 1	June and December	4⅝	4⅜
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½ 13½	12½ 13½	4 8 11	" "	..	..
15,000	10	6%	Do 6 per Cent. Cumulative 2nd Pref (£8 pd)	12½ 13	12½ 13	3 14 1	" "	..	..
350,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd)	105 107	106 108	4 3 4	..	107½	106½
58,000	5	1/0	United River Plate	2 3	2 3	..	January and July ..	..	..
£146,370	tock	5%	Do. 5 per Cent. Debenture Stock	85 95	85 95	5 5 8	—	..	..
			ELECTRICITY SUPPLY COMPANIES.						
1,000	£50	..	City of London Electric Lighting (£50 fully paid)	.. ..	.. ..	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	4½ 5	4½ 5	..	..	..	..
5,322	£5	..	House to House Electric	.. ..	.. ..	..	..	..	..
30,000	£5	..	Liverpool Electric Supply (£3 paid)	.. ..	.. ..	..	..	..	..
111,000	5	..	London Electric Supply	1¾ 2	1¾ 2	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	9¾ 10¼	9¾ 10¼	..	..	10½	9¾
7,730	£5	3/6	St. James' and Pall Mall	6¾ 7¼	6¾ 7¼	—	..	7 1/16	6⅞
..	..	7%	Do. 7% Preference	4¼ 4¾	4¼ 4¾	—	..	..	..
42,853	5	..	Westminster Electric Supply (£5 paid)	5¼ 5⅝	5¼ 5⅝	..	..	5⅝	5½
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978		..	Brush Electrical Engineering	2½ 2¾	2⅝ 2⅞	..	..	2⅞	2 9/16
69,996		6%	Do. 6 per Cent. Preference	1⅞ 2⅛	1⅞ 2⅛	5 12 11	June and December	2	1⅞
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	4½ 5½	4½ 5½	6 7 3	January and July ..	..	..
17,130	5	..	Edison and Swan United	.. ..	.. ..	..	—	..	..
45,000	10	6%	Electric Construction	3½ 4½	4¼ 4¾	..	—	4 1/16	4
70,000	2	10/0	Elmore's Patent Copper Depositing	3¾ 4	4⅛ 4⅜	..	—	4⅛	3 15/16
20,000	5	..	Fowler-Waring Cables (£4 paid)	2 3	2 3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	19 20	19½ 20½	4 17 7	February & August	19¾	19½
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	104 106	104 106	4 4 11	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	7½ 8½	7½ 8½	11 15 3	..	..	..
11,334	£10	5/0	Do. Preference	9¼ 9¾	9¼ 9¾	8 4 1	..	..	..
78,949	5	2/1½	Swan United (£3. 10s. paid)	4½ 5	4⅜ 5	6 19 10	May and November	4 7/16	4⅜
37,350	12	12/0	Telegraph Construction and Maintenance	42 44	42 44	5 9 3	March and July....	43½	42½
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101 104	102 105	4 15 3	January and July ..	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£2. 10s. paid)	.. ..	.. ..	..	..	..	..
—	£5	..	Do. Preference (fully paid)	.. ..	.. ..	..	..	..	..
			RAILWAYS.						
50,000	£10	..	City and South London Railway	3 5	3 5	—	—	..	..

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THE ELECTRICIAN:

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NOTES.

The Lauffen-Frankfort transmission experiment and the International Electrical Congress have drawn a considerable number of English and Continental electricians to the Exhibition; and the Congress, which opened on Tuesday, was attended by an audience of over 600. The value of such gatherings is considerable when there is anything definite to discuss, especially if there are any matters upon which resolutions can be taken. But the passing of such resolutions, if they are to carry any weight with the scientific or with the industrial world, cannot be left to a self-elected assembly. In this instance it is true that there was in one sense a representative body of English electrical engineers at Frankfort, since the Electrical Trades Section of the London Chamber of Commerce, instead of going for a picnic in a steam launch, had arranged an excursion to see the Exhibition; and as there were, we believe, about twice as many members at Frankfort as are generally to be found at Botolph House, they may be considered fairly representative. The Congress was divided into four sections, dealing with, (1) Theory and Measuring, (2) Powerful Currents, (3) Telegraphy and Telephony, (4) Electro-Chemistry, and a fifth section was subsequently formed to consider legislative matters, particularly the relations between the supply of currents for lighting and power, and telegraph and telephone circuits. As far as the Papers are concerned, we shall welcome any valuable ones, but shall not be surprised if the majority do not rise above the holiday style that is considered good enough for the British Association.

No small proportion of the interest which was taken in the recent Paper read by Mr. Ll. B. Atkinson and Mr. C. W. Atkinson, before the Institution of Civil Engineers, was due to the fact that no previous description of the construction or working of their coal-cutting machinery had been published. The conditions of safety and the economy of transmission of power were dealt with at greater length during the discussion than the mechanical details of the tools. It appeared to be admitted that the rock drills, both rotatory and percussive, were in a less developed condition than the coal-cutting machines; and for this reason we have omitted illustrations and parts of the discussion relating to them in the abstract of the Paper which is commenced this week in another column. We shall thus condense the long discussion into about one-half, without omitting all the extraordinary criticisms which were offered. It is difficult to say whether the Professor of Mining talking about electrical engineering, or the Science Professor talking about mining, distinguished himself the most. The Paper, besides describing a new and important application of motors, was a challenge to the advocates of transmission of power by compressed air. Between their confusion as to what is meant by the efficiency of transmission, and the mixture of facts and hypothetical improvements, they made so sorry a show that electric motor makers need have little fear of their competition.

A modified form of the Boulengé chronograph has recently been designed by Capt. H. Holden. This instrument is intended chiefly for measuring the velocities of projectiles, and short intervals of time are recorded and measured by marks made upon a falling rod. Two magnet circuits are provided, by one of these a rod is released, and during its fall another magnet brings up a knife edge, which makes a mark on the rod. A considerable number of adjustments and subsidiary mechanical devices have been introduced. The time is found from the formula $t = \sqrt{2\,h/g}$, and the value of g is given as 32·1908: but although a four-figure accuracy seems to be aimed at in the details given in a descriptive pamphlet, no table is given for the value of g at different places. There is a difference of more than one in a thousand between the value of g at Aberdeen and at Bordeaux or Turin; and if the instrument is capable of recording to within one tenth per cent. allowance must be made for the variation in the force of gravity. As far as we understand the instrument, the magnets are not arranged to do exactly the same mechanical work, and, therefore, it seems probable that the latency, or time which elapses between the breaking of the circuit and the action of the magnet, may introduce a much more serious error than will be produced by variation in the force of gravity. Sir William Thomson appears to have overlooked the correction for g in connection with his standard balance instruments, but attention was directed to it by Prof. Carey Foster, at the Electrical Standards Committee of the Board of Trade. In this case, the matter concerned this country only, yet the variation, though small, is appreciable, there being no kind of measurement in which greater accuracy is possible than in the delicate process of weighing. The difference between the value of g for Edinburgh and for Greenwich is 377 in a million.

A familiar item in both hypothetical estimates of the cost of steam power, as well as in actual accounts of expenses, is "oil

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and waste" at so much a day. It would seem that Mr. FERRANTI intends to treat the lubricant for his dynamos as part of the plant and include it in the capital outlay, for the 300 H.P. dynamo which has been running for some time at Havre has been using the same oil over and over again for eighteen months. A circulating pump is employed, but on a very different scale to the wiper by which gas engines and marine engines dole out a drop at a time. The bed-plate contains a reservoir, and a pair of pumps throw a liberal supply through copper tubes, which are connected to wide channels in the white metal lining to the bearings. Oil dealers, like mustard manufacturers, probably make their fortunes out of what is wasted rather than what is used.

ON a recent occasion we alluded to the relation between the patent system and modern Socialism. A patent creates a property, and enables any man who has the requisite ability to turn the product of his own brains into an important form of wealth; it offers great encouragement to individuals, and affords an opportunity for any man to rise by his own exertions above his fellows. This opposition to the socialistic principle of uniformity is accidental, and, as far as we are aware, it is not recognised by social politicians. But another relation between patents and an important economical principle has turned up, and Mr. J. P. WILLIAMS, the Liberal Member for South Birmingham, in searching for some corner into which Free Trade has not penetrated, finds "a considerable grievance, namely, the extraordinary disadvantages under which an Englishman taking out patents abroad, labours, as compared with the treatment of foreigners in this country who take out patents." There is a vestige of truth in the grievance, but this, again, may be said to be accidental. The fees for foreigners are, we believe, the same in all countries as for the patentees of each country. In the United States and in Germany there is a more or less careful examination as to the novelty of the invention. In the former, the routine is often very dilatory, and a brisk local agent is sometimes needed. In the latter, we have heard of a few cases in which English applications have been refused on unreasonable grounds, but, after making allowances for the natural irritation of an inventor on being told that he is not the first, we are inclined to attribute many of these rejections by the German patent office to want of tact on the part of the patent agent in refuting the objections. As for the conditions of working the inventions in the country which grants the patents, and using native made machinery for manufacturing the patented articles, they are but part of the principle of Protection. Until lately these conditions were construed very liberally in France, but it is difficult to see how any country which adheres to Protection can do otherwise than enforce them. Free Traders should, instead of grumbling at the completeness of foreign Protection, comfort themselves by reflecting on the folly of any nation attempting to set itself up as self-supporting and independent of external help.

The Tangier-Tarifa Cable.—This cable was opened for service on Tuesday.

Dublin.—The contract between the Corporation of Dublin and the Electric Engineering Company of Ireland was completed on Saturday last.

Church Lighting.—It has been resolved to adopt the electric light for the lighting of Holy Trinity Church, one of the largest churches in Bournemouth.

Brighton.—The Brighton Municipal Electric Lighting station was inaugurated on Monday evening last, the light being switched on by the Mayoress.

Prof. Helmholtz.—An address of congratulation, signed by the Principal and Professors of Glasgow University, was forwarded to Prof. von Helmholtz on the occasion of his seventieth birthday.

Appointment Vacant.—The Chair of Physics at the University College of Wales (Aberystwith) is vacant. The commencing salary is £200. Further particulars will be found in our advertisement columns.

Obituary.—C. A. Nyström, who was for many years the chief of the Technical Department of the Swedish Telegraphs, and a frequent writer on telegraphic subjects, died at Gothysgard, near Wadsbro, Sweden, on August 19th, aged 60.

Dundee.—The Electric Lighting Committee of the Dundee Gas Commission having approved of the report on the question of electric lighting, recommended its adoption at the last meeting of the Board. The report was unanimously adopted.

The Lauterbrunnen-Murren Mountain Railway.—This railway, which consists of two portions, that between Lauterbrunnen and Grütschalp being operated by rope, whilst the rest is worked by electricity, commenced work on August 14th.

New Cable to Mauritius.—Tenders are invited by the Government for the laying and maintenance of a cable from the east coast of Africa, near Zanzibar, *viâ* the Seychelles, to Mauritius. Particulars will be found in our advertisement columns.

Society of Engineers.—The next ordinary meeting of this Society will be held at the Town Hall, Westminster, on Monday, October 5th, when a Paper will be read on "Retort Charging and Discharging Machinery for Gas Works," by Mr. Henry O'Connor.

The Telegraph in Siam.—There are nine telegraph lines in operation in Siam, having a total length of 1,780 miles. The longest line is that between Bankok and Chiengmai (450 miles). Three other lines are at present under construction, amounting to a length of 710 miles.

The West End Street Railway, Boston.—The August returns of the West End Street Railway of Boston show in a striking manner the reduced cost of motive power consequent on the coming into operation of the large new generating station. The motive power for an electric car has now been got down to seven cents per car mile.

Stockholm.—The Swedish State Telegraphs and the Stockholm municipal authorities have some little trouble in agreeing, the Telegraph Department objecting to comply with certain somewhat stringent regulations which the Municipality has seen fit to introduce recently. The matter has now been brought before the Government.

Electric Lighthouses.—In the course of next year the two powerful electric lights on the headland of La Hêve, near Havre, will be entirely altered. The Southern light will be extinguished, and for the present one in the North tower a 5-seconds flashing light will be substituted. The new light will, it is said, be 500 times as strong as the old ones.

A Portable Mining Pump.—The Goulds Manufacturing Company, of Seneca Falls (N.Y.), has recently brought out a triplex electric pump, intended to meet the special exigencies of mining work. It consists of an electric motor geared to a triplex pump and mounted on a little tram car that can be readily moved about on the ordinary mine tramways.

Frankfort Exhibition.—We learn from the *Electrotechnisches Echo* that Prof. Kittler has resigned the chairmanship of the jury, and that Prof. Kohlrausch has undertaken the duties in his stead. The work of the jury is in full swing. Some of the larger exhibitors, such as Siemens and Halske, the Helios Company, Fein and Co., &c., have refused the awards made them.

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A New Use for the Electric Car.—Recently two Italians near Gravesend, Long Island, after committing a murderous assault on a fellow-countryman, tried to escape by running down the road towards Brooklyn. The conductor of an electric car, who had heard of the assault, immediately gave chase, overtook the men and captured them.

Hove.—At the last meeting of the Hove Commissioners the common seal was ordered to be affixed to an agreement for the purchase of a piece of land intended to be used for the purposes of the electric light. It will be seen by our advertisement columns that the Commissioners are prepared to receive proposals with regard to the taking over of their electric lighting order.

Royal College of Science, Dublin.—The autumn term of the Session 1891-92 of this College will commence on Monday, October 5th. The Royal College of Science supplies courses of instruction in the sciences applicable to the industrial arts, especially those which may be classed broadly under the heads chemical manufactures, engineering, and mining. Full particulars will be found in our advertisement columns.

Electric v. Horse Traction.—Referring to the forthcoming Street Railway Convention in Pittsburg and to the opposition to electric traction still persisted in by a few street railway men, the *Electrical World* opines that "street railway companies are by no means in business for their health, and if traction by horses really paid better than that by electricity, to find an electric road would require a professional detective."

The Portrush Line.—There was a narrow escape from a bad accident on the Portrush tramway line a few days ago. A steam tram left Portrush at nine o'clock, and at the same hour an electric car left the Giant's Causeway. The steam tram overran the passing place, and met the electric car some little distance further on. The passengers on the electric car became greatly alarmed, and some jumped off. The cars were, however, brought to a standstill just in time.

Launceston (Tasmania).—The Launceston City Council at a recent meeting adopted a report of the Public Works Committee recommending a scheme for supplying the city with electricity for public and private lighting, and for motive power, at an estimated cost of £50,000. The idea is to utilise the water of the South Esk for the generation of the necessary power. The water will be conveyed in pipes to a place where the available head will be 250ft., giving about 850 H.P.

Telegraph Extensions in France.—By a recent Parliamentary vote the French Government was granted some £29,000 for the purpose of improving the foreign telegraphic service. Two wires 500 miles long are to be run from Paris to the Pyrenees, to directly connect Paris and Madrid and Paris and Lisbon respectively. A wire 150 miles long will be run between Bordeaux and Bilbao, and another of 250 miles will be run to the German frontier. Finally two 210-mile wires will connect Paris to Calais.

Eastbourne.—At the monthly meeting of the Town Council on Tuesday last week, the Lighting and General Purposes Committee reported that the borough surveyor had submitted a letter from the manager of the Eastbourne Electric Light Company, stating that the charge in the proposed new contracts would be 10d. instead of 1s. per unit, representing a reduction of nearly 17 per cent. in the price. It was resolved that the borough surveyor be authorised to sign the contracts on behalf of the Corporation.

Thunderstorms.—Thunderstorms, writes our Scandinavian correspondent, continue unusually frequent in Scandinavia. On Sunday, August 23rd, not less than five persons were killed by lightning in the Vestergothland district, in Sweden, in addition to which several persons were injured. On the 26th two persons were killed at Saxhusa, not far from Lund, in West Sweden. On the night of September 3rd a tremendous thunderstorm raged all over Denmark. News has been received of about sixty fires caused by the lightning.

Chicago Exhibition.—Sir Henry Wood was presented to the President of the United States on Tuesday, and on Thursday proceeded to Chicago. The Secretary of the Treasury had a conference with the Exhibition officials on Wednesday, at which Sir H. Wood attended, as also did the German Commissioner, to arrange modifications of the Customs regulations affecting the exhibits coming to the Exhibition. The Secretary said he would do everything possible to meet the needs of foreign exhibitors, and where modifications of existing laws were necessary he would cheerfully recommend amendments to Congress.

Telephone Trunk Wire Development in the West of England.—The Western Counties and South Wales Telephone Company has already spent some £50,000 on trunk lines, and an additional expenditure of £30,000 will be required before the extensions at present contemplated are completed. It is expected that Bristol will be in telephonic communication both with London and Exeter within the next twelve months. To show the development of interurban telephonic communication, it may be stated that the calls between towns on the trunk lines in August, 1888, numbered 13,212; in August, 1889, they rose to 15,889; in August, 1890, to 22,253; and in August of the present year to over 28,000, or an increase of 112 per cent. in the four years.

The Production of Asbestos in the United States.—Asbestos is found in the United States in Pennsylvania, Maryland, Virginia, North Carolina and South Carolina, and Georgia. It is inferior in quality to the best that is mined in Italy or Canada. Asbestos is also found in considerable quantities in California and Wyoming. The production of asbestos in the United States has shown an annual decrease since 1882. The product for 1882 was 1,200 tons (short); 1883, 1,000 tons; and 1884, 1,000 tons. The output for 1885 showed a decided drop, being only 300 tons, and this was again reduced to 200 tons in 1886, and 150 tons in 1887. In 1888 the output was 100 tons, valued at $30 per ton. In 1889 the only asbestos came from California, amounting to 30 tons.

Callendar Electric Pyrometer.—In a recent number of the *Philosophical Magazine*, Mr. H. L. Callendar describes a modified form of the well-known Siemens electric pyrometer. In the Siemens pyrometer the zero is known to change largely and continuously. Mr. Callendar, however, points out that this effect is due to imperfect design, and he claims that if the wire is pure to start with, and is protected while in use from strain and from contamination, its resistance, after having once been annealed, is always very nearly the same at the same temperature. Mr. Callendar's improvements in the platinum resistance thermometer, or pyrometer, consist in the better protection and treatment of the platinum wire. This is differently treated, according to the heats to which it is to be exposed. Two recent communications to the Royal Society related to investigations carried out with the aid of the platinum thermometer.

The Application of Hydrocarbon to Arcs.—In order to overcome certain objections attendant upon the employment of tubular carbons, by which a supply of hydrocarbon may be introduced "to intensify and improve the quality of the light," Mr. W. S. Richards, of Natich, Mass., binds a refractory capillary conductor to the outside of a solid carbon. The chief objection which he thus overcomes is that the hollow carbon is patented by Mr. Saunderson, and a more simple and literal evasion it is difficult to imagine. We alluded to Mr. Saunderson's lamp on p. 594 of our last volume, and have heard nothing more of the idea. It is difficult to see what advantage can be obtained, except by the lengthening of the arc, and, therefore, a lessening of the obstruction of the light of one carbon by the other.

Inverness.—At a meeting of the Inverness Police Commissioners held on Monday, attention was directed to the report of the Manager of the Corporation Gas Works, in which it was stated that owing to the yearly increasing consumption of gas in the town, additional machinery and holders would soon be required at the Gas Works, the cost of which he estimated at about £10,000. Bailie Ross thought that the Commissioners, before embarking on such a heavy expenditure, should consult a practical engineer on the subject of lighting the town by electricity. It had, he said, been suggested that the necessary motive power might be obtained from the River Ness, or from Loch Ness, or even from the Fall of Foyers. He formally moved the appointment of a Committee to make full inquiry into the whole scheme of electric light being introduced into the town.

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The Liverpool Electric Inspector's Fees.—The following is the draft scale of charges for testing to be paid by the Undertakers under the Liverpool Electric Lighting Order, 1889, to the Electric Inspector.

Tests to be taken.	Fees. s.	d.
Insulation resistance (in ohms) of main, each test	5	0
Conductivity (in mhos) of main	7	0
Insulation resistance of service line	2	6
Conductivity (in mhos) of service line	4	0
Insulation resistance and copper resistance of joint	3	6
Tests of energy at testing stations, per diem	2	0
Tests of energy at generating stations, per diem	1	6
Tests of instruments owned by undertakers, per instrument	1	0
Earth leakage tests under pressure, per station per diem	1	0

The Faure Accumulator Patent in Germany.—The action for the annulment of the Faure patent brought against the Joint-Stock Accumulator Company of Hagen (Westphalia), by the Berlin Accumulator Company, Correns and Co., de Khotinsky, Gelnhausen, and Gottfried Hagen of Cologne, came before the Imperial Patent Office on Thursday, last week. All motions made by the petitioners for annulment, in order to obtain a postponement of the case, the institution of experiments, hearing of witnesses both in this country and abroad, were disallowed, it being decided that sufficient material was already before the Court to admit of a decision being arrived at. The Imperial Patent Office granted the demand of the defendants' counsel that the appeal lodged by the petitioners should be disallowed, thereby declaring the validity of Faure's 1881 patent to be unconditional.

India-rubber in Madagascar.—Among the forests of Madagascar, india-rubber is everywhere to be found, but, says the Chancellor of the French Residency at Antananarivo, in those places which are easy of access it is beginning to be scarce, and the prices have considerably increased. The diminution in the supply is to be attributed, among other causes, to the cutting of the trees at the foot, in order to more easily arrive at the milk. India-rubber enters, to a very great extent, into the exports of the country, and, in order to encourage this industry, the Government ought, in M. Anthouard's opinion, to look carefully after the preservation of the forests, endeavour to prevent fires, and to induce the natives to abandon their habit of cutting down the trees bodily. In these circumstances, Madagascar india-rubber might, he thinks, successfully compete with the Para product.

The Montefiore Electro-technical Institute.—In common with similar institutions in this country, the well-known Montefiore Electro-technical Institute at Liége has rapidly developed since its foundation in 1883. At the present moment no less than 201 students attend the lectures and practical courses presided over by Prof. Eric Gérard; of these than 45 per cent. are foreigners, 5 being Englishmen. Owing to the rapid growth of electrical science and the constant increase in the number of students, the original laboratories and lecture rooms of the Institute had recently become quite inadequate. The Belgian Government, however, recognising the good work of the Institute, has now placed the spacious edifice formerly occupied by the École Normale des Humanités at its disposal, together with the necessary funds for its transformation, and the munificence of M. Montefiore has enabled the new premises to be fitted up in a manner worthy of the traditions of the Institute. The new home of the Montefiore Institute will be ready in October, when the autumn session commences.

Bradford.—At the last meeting of the Town Council the chairman of the Gas and Electricity Supply Committee moved the adoption of the minutes of that committee. The chairman made a statement of the result of the working of the electricity department for the half-year ended June last. He said that the total receipts during the half-year amounted to £2,093, including stock amounting to £109. The total expenditure, including stock at commencement, which was £110, amounted to £1,261, leaving a balance towards what might be called gross profit of £832. For interest on loans there had been paid £469. 16s. 10d., and for sinking fund £392. 16s. 8d., making a loss on the half-year of £30. 5s. 4½d. One hundred and fifty pounds which had been received during the half-year had been placed to capital account. If that had been put down to revenue account there would have been a profit of £120, in addition to interest and sinking fund. The losses on the department since it was commenced were as follows:—First half-year, £1,079; second half-year, £732; third half-year, £315; and last half-year, £30; making a total of £2,157. The amount transferred to the sinking fund to date was £1,942. 9s. 8d. He thought, although nothing had been taken off for depreciation, there was every prospect that the next time the balance-sheet was presented it would show a profit in addition to the payment for interest and sinking fund.

Patent Law in Germany.—Owners of German patents who reside out of Germany would do well, says the Berlin correspondent of *Industries*, to pay more attention to the section in the law relating to patents which provides that the invention embodied in the patent must be manufacured in Germany within a period of three years from the granting of the patent. Some important points in this connection were dealt with in a recent judgment. It was decided that the owner of a patent cannot escape the provision of the law as to the duty of manufacturing the subject of the patent by contending that the demand for it is insufficient to pay the cost of production or of the erection of machinery necessary for carrying on its manufacture. The owner of the patent is required to make every effort to create a demand in the market, and, above all, to manufacture the subject of the patent for that purpose. From these provisions it will be gathered that the German patent law lays especial stress on the duty of a patentee to bring his patent into active operation. It is difficult to give any more exact information to the patentee, as the law only contains a general provision that the subject of the patent must be introduced in Germany to a suitable extent. The judge decides each case on its own merits, with due regard to the special circumstances of each patent, and tries to discover whether a real attempt has been made to introduce the subject of the patent into Germany.

The Board of Trade and Steam Pipes.—The Board of Trade have instructed their surveyors that all new steam pipes are to be tested by hydraulic pressure to not less than twice, and not more than two-and-a-half times the working pressure, unless the case has been specially submitted to the Board for consideration. As regards old steam pipes, for a period of six months from the date of the instruction the surveyors may exercise their discretion as to the test pressure they apply—taking care that such test does not exceed twice the working pressure, and that when it is less than twice the working pressure, the declarations granted are limited to a period not exceeding six months. If in any case the surveyors cannot get such a test pressure applied to old pipes as they consider necessary, they are to forward full particulars of the case to the Board, in order that the necessary directions may be given. After six months from the date of the instruction old steam-pipes are to be tested to a pressure of at least double the working pressure; but double the working pressure is not to be exceeded unless the case has been referred for consideration. The surveyors may test steam-pipes at any time they consider necessary; but, except in special cases, possibly once in about three or four years may be found sufficient. When steam-pipes are tested, the lagging or covering is to be off the pipes, and the pipes are to be carefully examined before, during, and after the hydraulic test. The surveyors are to see that efficient means are provided for the draining of all the steam-pipes.

Priority in Alternating Current Motors.—In its issue of September 2nd, the *Electrical Engineer* of New York alludes to the Tesla-Ferraris priority controversy in the following terms:—"In his essay of March, 1888, Prof. Ferraris expressly denied the practicability of motors that Mr. Tesla already had in successful operation! He hinted at the possibility of using a proper generator for such motors, but no further did he go. Mr. Tesla had already taken coal out of the mine before Prof. Ferraris made his geological survey of the region. With this admission from Prof. Ferraris, it was not very likely that practical men would recognise the great value of the new principle. On examination of Mr. Tesla's now familiar work, we find that he, on the contrary, had not stopped short at a mere rotating field, but dealt broadly with the shifting

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of the resultant attraction of the magnets; that he had evolved the multiphase system; that he had shown the broad idea of motors employing currents of differing phase in the armature with direct currents in the field; that he first described and used an armature with a body of iron and closed coils symmetrically wound; that he had shown both synchronising and torque motors; that he had shown how machines of ordinary construction might be adapted to his system, and had with specific purpose advanced boldly into new territory, of which there was not the slightest hint or suggestion in the work of Prof. Ferraris. In other words, Mr. Tesla not only went to the bottom of the fundamental principles, but tried them in every detail that inventive ingenuity could hit upon. If this is not so, it is time to have the contrary state of affairs proved before Mr. Tesla loses the credit that such work must give him."

Smoke Annihilation.—Among the innumerable devices which have been pressed into service for the purpose of mitigating the smoke nuisance, specially designed furnaces have not been forgotten. The main object of a system employed by the Gaseous and Liquid Fuel Supply Company is to furnish a secondary supply of heated air at the back of the fire bridge. The air, after passing under the fire grate, goes through an opening at the bottom of the fire bridge, and coming into contact with the carbon monoxide and hydro-carbons which have escaped combustion, consumes these gases, rendering them useful by utilising the heat produced in their combustion. There is a drop arch placed at the point where the heated air supply enters, which arch, becoming incandescent, maintains the temperature necessary for the secondary ignition. That the combustion is achieved in a satisfactory manner the following analysis, says the *Chemical Trade Journal*, will show. The coal employed gave upon analysis:—

Fixed carbon	54·22
Volatile matters, chiefly hydrocarbon, with some sulphur	28·35
Moisture	4·70
Ash	12·73
	100·00

Upon testing the residual gases which were obtained by taking a sample over a period of two hours from the boiler flue, the following results were obtained:—

Nitrogen	83·47
Oxygen	0·69
Carbon dioxide	15·01
Carbon monoxide	0·83
Sulphur dioxide, Free hydrogen and hydrocarbons	Absent.
	100·00

It thus appears that the whole of the hydrocarbons were removed by complete combustion, and the carbon monoxide present practically so, there being less than 1 per cent. present. That an economy is effected by thus obtaining more perfect combustion is proved by the fact that the hydrocarbons, usually allowed to escape unburnt, contain $\frac{3}{10}$ths of the heat of the original fuel, besides rendering the "economisers" more efficient by preventing the formation of sooty deposits upon the tubes.

The Telephone in Madrid.—The telephone made its appearance in Madrid, says M. Pierard in *l'Electricien*, in November, 1883, under State superintendence; the exchange subscribers numbered about 650, more than one-third of whom were officials. In September, 1886, the Madrid Telephone Company took over the business, the Government having worked it at a loss of some £2,000 per annum, and having refused the money necessary to render the system efficient. The Company has an authorised capital of £72,000, of which half has been called up. The exchange subscribers now number some 1,800, or about one to every 270 inhabitants. Ader transmitters and receivers are employed. The circuits are twin-wire and overhead. By a municipal decree no bare overhead wire of a greater length than half a kilometre is allowed, cables are consequently largely used; these are made by Rattier of Paris, and contain 12 7-strand $\frac{1}{10}$mm. wires, and weigh 1,160lb. to the mile. The cables are suspended by steel hooks placed four metres apart, from a 3mm. steel bearer wire. The overhead wires are of silicium bronze and 1·1mm. in diameter. The central exchange is situated in the upper stories of the Hotel de Madrid, the circuits all running to a huge circular metal tower. There are three auxiliary exchanges. There is no need for a multiple switchboard in Madrid, and an old-fashion board, made by the Compagnie des Téléphones de Paris, has proved quite equal to allowing the necessary connections to be effected for the average daily 7,000 calls. The annual rental was originally £24, and is at present £12. For points more than three kilometres from the central office four francs extra per 100 metres is demanded. Two public call offices have been opened, the charge being threepence per five minutes' conversation. The "theatrephone" has found considerable support. The instruments are installed at the "Continental Express" office. A pair of telephone receivers may be had for the entire opera season for £24, which amounts to 4s. per performance.

The Moebius Process.—The *Engineering and Mining Journal* of May 9th, contains an interesting account of the Moebius process of electrolytically separating gold from silver, as carried out at Pinos Altos, Chihuahua, Mexico. This process consists essentially of a mechanical brushing arrangement for keeping the cathodes free from the electro-deposited silver crystals. Oiled muslin bags surround the anodes to collect the separated insoluble substances, and beneath the cathodes there are trays for catching the silver scraped off by the brushes. The electrolyte, which is kept continually agitated, consists of a solution of nitrate of copper, nitrate of silver, and free dilute nitric acid. The silver only is deposited, and whatever copper there is, is left in solution. The *raison d'être* of the nitrate of copper is to make sure that all the lead present is converted into insoluble peroxide at the anode. The gold, platinum, antimony, peroxide of lead, &c., separate at the anodes and fall into the muslin bags. When too much copper has accumulated in the solution, the electrolyte can be regenerated by a simple electrolytic process. The plant at Pinos Altos has a capacity of 3,500 to 4,000 ounces of doré silver per 24 hours, and consists of a tank 12ft. in length, 2ft. wide, and 20in. in depth, divided into seven compartments. Four pure silver sheets are placed in each compartment, as cathodes and six doré bullion plates as anodes. The manual labour connected with the process is very light. Every 24 hours the separated silver and gold is removed. This is done by turning a crank, by means of which the electrodes, the trays containing the silver, and the bags containing the gold, &c., are raised up, leaving only the liquid in the cells. A movable tank on castors, provided with a filtering bottom and a chute extending under the silver trays, is pushed alongside the battery. By removing the pins holding the bottom of the trays, the silver drops on the chute and into the tank. After a superficial washing the silver is ready to be dried and melted into bars of ·999 to 1·000 fine. The bag frames containing the gold are also removed and turned into a tank filled with water, and also provided with a false bottom. The gold is filtered by drawing the water from the tank, dried and melted, whereby the lead and other impurities go into the slag. All the operations are very simple, and skilled labour is uncalled for. The process is a very clean one. There are no fumes and noxious gases, no handling and transferring of solutions. The current employed is 170 amperes, at about 8 volts, which corresponds to an expenditure of only 2½ H.P. for parting 3,500 to 4,000 ounces per day. The doré silver is cast into anode plates 10in. long and 8in. wide, and from $\frac{3}{16}$in. to ¼in. in thickness; the plates weigh, on the average, about 100 ounces. In each of the seven compartments there is room for six plates; therefore it takes 42 plates, or about 4,200 ounces of bullion, to fill the apparatus at the start. The stock solution contains variable quantities of silver up to 300 ounces. The cathodes, which are made of pure silver, represent an intrinsic value of about $1,000. In the United States the process has been in successful operation at the works of the Pennsylvania Lead Company, at Pittsburgh, since September, 1886, where 30,000 to 40,000 ounces of doré bullion are separated daily. The first plant was erected at the works of the Kansas City Smelting and Refining Company. The St. Louis Smelting and Refining Company has lately contracted for a plant of a capacity of 35,000 to 40,000 ounces a day.

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MAGNETISM IN IRON AND OTHER METALS.*—L.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 519.*)

§ 173. **Group of Four Members.**—A better approximation to the facts will be obtained if we deal with a group consisting of four little magnets, with their centres at the four corners of a square (Fig. 141). When the field H begins to act, the members of the group are all slightly deflected, but without at first becoming unstable. If during this first stage the force H is removed, there is no residual displacement. But when H is sufficiently increased the original lines of the group break, and the members tend to pair themselves anew in lines which are more favourably inclined to the direction

Fig. 141.

of H (Fig. 142). Finally, when H is further increased, the members of the group are gradually compelled to take the position sketched in Fig. 143. Next, suppose H to be removed. There will be a return from the condition of Fig. 143 to that of Fig. 142, but the pairing shown in Fig. 142 will be maintained, and this implies a large amount of residual magnetisation. If the direction of H be then reversed, and its value gradually increased, a stage will presently be reached when the resultant polarity of the group suffers an abrupt change through the reversal of the lines in Fig. 142.

The curve of magnetisation—that is to say, the curve showing the resultant polarity in terms of H—for the single group of four members is sketched in Fig. 144.

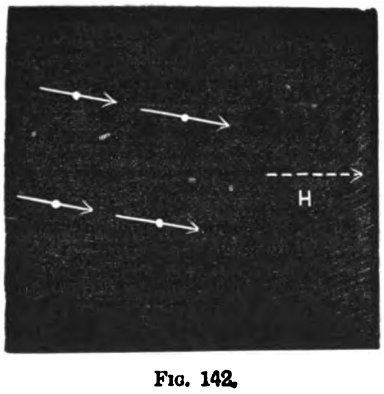

Fig. 142.

From this it is easy to see, in a general way, what would be the form of the curve for an aggregate of many such groups, variously inclined to the direction of H. The transition from one stage to another will be gradual in the aggregate, for it will happen at different values of H in different groups. Hence the curve will assume a rounded outline in place of the sharp corners of Fig. 144.

Moreover, the curve obtained during the removal of H will not coincide with that obtained during the application of H, except the process be stopped at a very early point in the first stage. Whenever the process is extended far enough to cause any of the groups to reach the unstable state we shall find hysteresis. The two curves will not coincide, even in the third stage. Some of the members will pass through an unstable state even there. After the first re-arrangement of the group has taken place, and the lines have become directed as in Fig. 142, there may be second breaking up and passage through instability on the way to the state of Fig. 143. This will happen when the lines of centres have a considerable inclination to H, and especially when the poles of the members are close together. In such an aggregate of groups we may therefore expect to find hysteresis in all possible cyclic changes of the magnetising force. The form of the curve obtained during reversal of H will evidently agree with the general form given by the magnetic metals. In proportion as the corner between stages 1 and 2 in the first curve is comparatively sharp or comparatively rounded so will be the corner at which the rapid descent of the curve begins while H is being reversed.

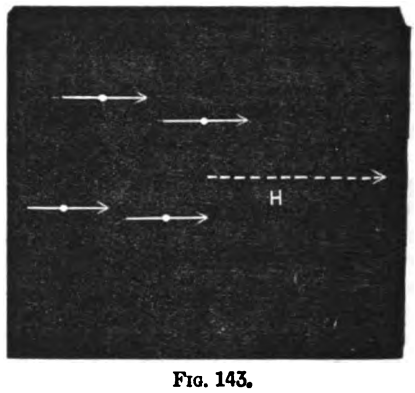

Fig. 143.

§ 174.—**Continuous Distribution in Cubical Order.**—From these considerations regarding groups of four members it is easy to pass to the case of a manifold group or a continuous distribution of members arranged so that the lines of centres form squares. All that has been said above is still applicable. The members arrange themselves in lines, and each individual is mainly constrained by its two neighbours in the same line, instead of by one neighbour as in the case already spoken of.

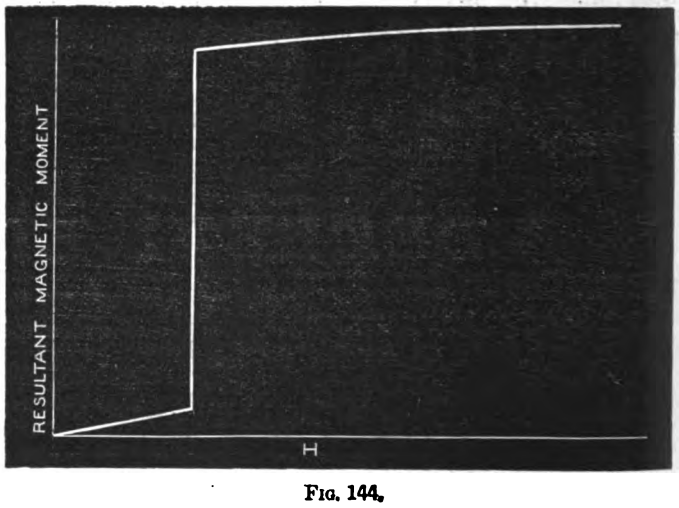

Fig. 144.

The equations of § 172 are readily adapted to members of a long row by substituting $2m^2$ for m^2 in the expression for the restoring moment. The three stages of (1) stable deflection, (2) instability, with rupture of the original lines and formation of new lines, and (3) further stable deflection are as readily traced as before, as will be evident by an inspection of Figs. 145, 146, and 147.

Fig. 145 represents an imaginary primitive arrangement. Fig. 146 is the configuration reached after the breaking up of the primitive lines, and Fig. 147 corresponds to saturation.

It appears, then, that the theory that the magnetic molecules owe their stability to the magnetic action of their neighbours gives results which agree with the observed facts, whether we conceive the molecular structure to consist of isolated groups, with a limited number of members in each, or to be continuous. Even with a continuous distribution the lines of molecules

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will, in consequence of the imperfect homogeneity of the piece, be variously inclined at various places, so that the condition necessary to give a rounded outline to the curve will in any case be present. In no piece, except perhaps in a single crystal, could we expect to find that perfect regularity of structure which would be necessary to make the transition from one stage of the magnetising process to another quite sudden, and to give the curve the form of a series of sharp steps.

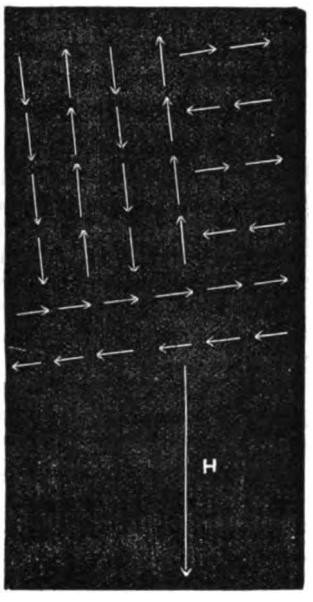

FIG. 145.

Whether we picture the structure as continuous or as built up of isolated groups, special importance attaches to square patterns from the fact that the magnetic metals crystallise in the cubic system. The behaviour of pyramidal forms presents some interesting features that need not be entered into here.

Enough has already been said to show that there is no need to assume that any arbitrary constraining forces act on Weber's

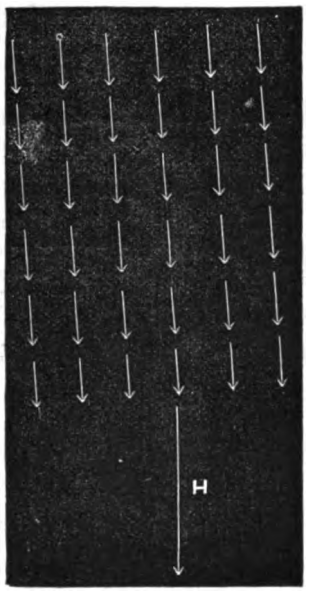

FIG. 146.

molecular magnets. The theory that their constraint proceeds only from their mutual action as magnets evidently suffices to explain, generally, the characteristics of the magnetising process. It may be useful, however, to point out how complete is the agreement, in point of detail, between the deductions which may be drawn from the theory and the facts which have been described in earlier chapters.

§ 175. **Agreement of the Theory with known Facts about Susceptibility.**—In the first stage there is no rupture of molecular ties until the magnetising force is sufficiently increased to bring about instability in the least stable lines or groups of molecules, and until that happens the application and removal of the force has no residual effect. Up to that point the deflections are small, and they are initially proportional to the applied force. All this is in complete agreement with Lord Rayleigh's experiments on the susceptibility of iron and steel to feeble magnetising forces (§ 87), which show that the initial value of the susceptibility is a small constant quantity, and that residual magnetism begins to show itself only when the magnetising force is so much increased that the proportionality of magnetism to force ceases. Again, it accords with the result that a small alternating change of H, superposed on a constant value of H, or acting on a piece which has residual magnetism in consequence of the action of previous forces, produces (after the first application) but a small coming and going of the molecules without breaking their ties, and that if this small alternating force is applied when the magnetisation is already strong, the changes which it causes are reduced in amount (§ 87). Again the theory might lead us to anticipate the fact that, if at any point of the ordinary magnetising process we stop increasing H and begin to decrease it, or stop decreasing

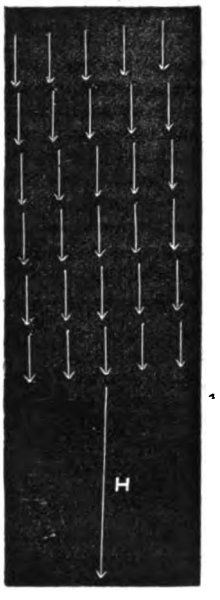

FIG. 147.

it and begin to increase it, the initial rate of magnetic change or value of $\frac{d\mathsf{H}}{d\mathsf{I}}$ is very small, depending, as it does, only upon the quasi-elastic return of the deflected molecules. Their movements through the condition of instability do not begin until the reversal of procedure has been carried some little way.

Again, in strong fields the behaviour of the little magnets accords with the gradually falling off in susceptibility which actually occurs in magnetic metals as the state of saturation is approached. To reach the state of perfect saturation would require an indefinitely strong directing force, but the alignment of the molecules is to all intents complete long before that. In view of the molecular theory it is not surprising that in iron, where many molecular groups break up under a force of no more than two or three C.-G.-S. units, a force of two or three thousand units produces (as we saw in § 102) so nearly perfect saturation that augmenting the force tenfold adds nothing perceptible to the magnetisation.

The quantity which tends to a limit when saturation is approached, is, as was shown in § 93-102, the intensity of magnetisation I, not the induction B. According to the molecular theory, I is the sum per unit of volume of the moments of the molecular magnets resolved in the direction of magnetisation. If n be the number of molecular magnets in unit volume, and m the moment of each, the saturation value of I is $m\,n$.

(To be continued.)

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THE LAUFFEN-FRANKFORT POWER TRANSMISSION.

COMMUNICATED BY GISBERT KAPP.

The distance between the generating station at Lauffen and the receiving stations in the Frankfort Electrical Exhibition is 175 kilometres, or about 110 miles. Power was transmitted over this distance for the first time on August 25th, when the current was supplied to about 900 16 c.p. lamps in the Exhibition, and a few days later the output was increased to 1,100 lamps. There are in the Exhibition two receiving stations, side by side, one for the production of power and the other for the production of light, both being connected in such a way that either power or light, or both together, may be obtained at will. The generator at Lauffen is a Brown "three-phaser," made and supplied by the Oerlikon Works, and the line consists of three hard-drawn copper wires of 160mils diameter, supported on oil insulators fixed to wooden poles 26ft. high. There have been erected in all about 3,000 poles, at an average distance of 200ft., and the total weight of copper in the line is 60 tons. At Lauffen there are three transformers. One of these has been made by the Oerlikon Works, and the two others by the Berlin Electricity Works. At Frankfort there are also three transformers, two made by the Berlin and one by the Oerlikon Works. The transforming ratio of all the six transformers is 1-160, and they are oil insulated. In the power station at Frankfort, which was fitted up by the Berlin Works, the current is used for working a 100 H.P. three-phase motor, designed by Herr von Dolivo-Dobrowolsky. The motor is coupled direct to a centrifugal pump, which supplies water to an artificial cascade 30ft. high. The lighting station at Frankfort has been fitted up by the Oerlikon works, and the lamps are arranged partly on a large signboard of ornamental design in the Exhibition grounds, and partly on lamp-boards in the Exhibition building, which serve for varying the load within certain limits.

Mr. Brown's generator at Lauffen has already been described in *The Electrician* of August 7th. The machine is separately excited, and a rheostat is provided, so that the attendant can compensate the loss of pressure in the line by adjusting the excitation. The common junction of the three armature windings is connected to earth, and the excitation of the field is so adjusted as to obtain from 45 to 60 volts between each branch and earth, according to the amount of power flowing out of the station. The common junction of the low-pressure primary circuits in the transformers is solidly connected to the common junction of the armature windings, and by means of a fuse, to the common junction between the secondary or high-pressure coils of the transformers. The object of this connection will be explained presently. According to the voltage of the three-phaser, the pressure between any line wire and earth is, therefore, from 7,200 to 9,600 volts, and the pressure between any two line wires from 12,000 to 16,600 volts, being $2 \times \sin 60$deg. of that in each branch.

The general arrangement of the circuits from the generating station at Lauffen up to the branches which lead to the power and lighting stations in the Exhibition may best be described by means of the annexed sketch, Fig. 1.

In this sketch G represents the generator or "threephaser," the three sets of coils being diagrammatically indicated by the three thick lines O I, O II, and O III, forming angles of 120deg. with each other. The primary or low-pressure coils of the transformer, T, are similarly represented by thick lines, and the three thin dotted lines o 1, o 2, o 3 represent the high pressure or secondary coils of the transformer. The generator coil O I is connected with the transformer coil O I, first by the earthed wire O O, as already mentioned, and also by an insulated circuit which contains an alternate current ampere meter A_1, a relay magnet R_1, and a fuse, F. The other two set of coils on the threephaser and transformer respectively are similarly connected. The voltage in the three branches is indicated by the three voltmeters V_1, V_2, V_3. The relay magnets are arranged for minimum and maximum current, and if the current in any of the three branches of the threephaser should fall short of the minimum, or pass beyond the maximum value for which the relays are set, the relay in that branch cuts off the exciting current from the field of the threephaser. The voltage obtained then in the low-pressure circuit at the generating station is simply that due to the residual magnetism in the threephaser, and therefore perfectly safe even in case of a short-circuit in the primary wires. It would, of course, have been possible to so arrange the relays that in case the current in any branch becomes abnormal from whatever cause, the motive power (in this case a 300 H.P. turbine) is automatically shut down. This would, however, be a somewhat drastic remedy, especially if the disturbance is of a trivial character and capable of adjustment without stopping the machinery. As soon as the exciting power and with it the load is taken off, the turbine begins to race, and this is, of course, immediately noticed by the man in charge at Lauffen, who may then use his discretion whether he will shut down or not.

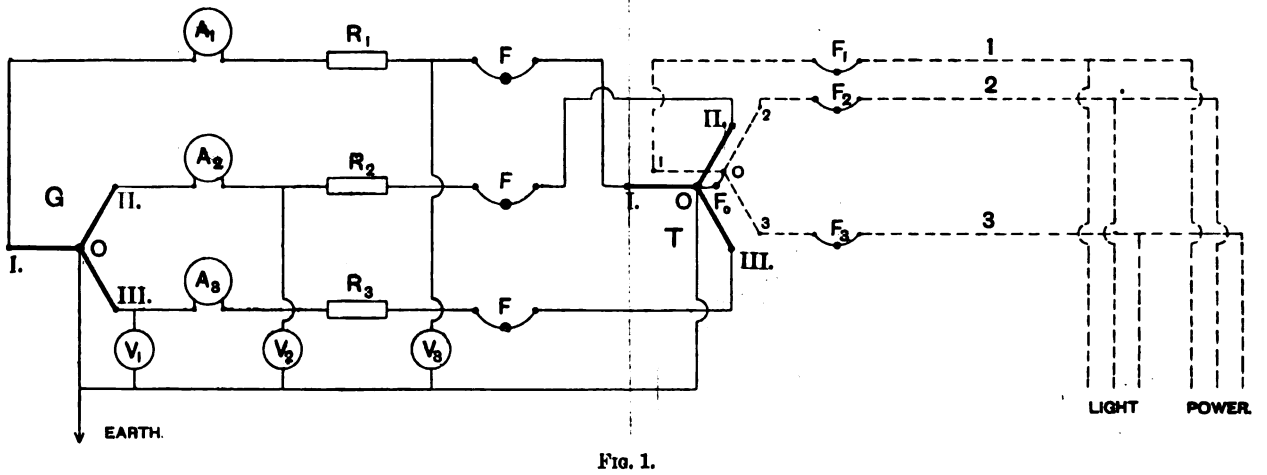

Fig. 1.

The fuses, relays, ampere meters, and voltmeters belonging to the low-pressure or primary circuit at Lauffen are mounted upon one board, which also contains the voltmeter and ampere meter for the exciting circuit, and the rheostats for the latter, by which the voltage of the threephaser is adjusted. In order to compensate for the ohmic resistance of the line, the attendant works by a table giving the primary voltage corresponding to various currents, so as to keep the pressure at Frankfort constant at varying loads.

It will be seen that the arrangements of switchboard and instruments at the generating station are of the simplest possible character. In the high pressure or secondary circuit there are no switches, but merely three fuses, F_1 F_2 F_3, as shown in the diagram. To make a fuse for 10,000 volts is not an easy problem, but it has been solved by Ferranti and others, and any of the existing forms of fuses might have been accepted for Lauffen. Since it is, however, the intention of the two firms

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who have carried out this transmission plant to work later on at double the present pressure (by using two transformers at each end with their thick wire coils in parallel and their thin wire coils in series) it was thought safest to arrange the fuses in such a way that there can be absolutely no doubt as to their satisfactory working even at 20,000 or 30,000 volts. The method of mounting fuses on a board inside the station has, therefore, been abandoned, and the fuses have been placed out, side, where they form part of the line. As already mentioned, the line wires are 160 mils. in diameter. Close to the generating station there is a short piece of line in which each of these circuits consists of a pair of copper wires of only 6 mils diameter, and about 8ft. in length. There are two posts placed that distance apart to which the line wires are shackled, and the fuse wires serve to bridge the space between the posts. To facilitate the renewal of the fuses the posts are provided with steps. This provision is necessary because the line is at Frankfort frequently short-circuited on purpose to advise the man in charge at Lauffen that he may shut down. For this purpose there is suspended over the three line wires at the Exhibition an angular stirrup or bridge of iron, which can be lowered by a cord so as to make metallic contact between the three wires. The fuses at Lauffen are thereby melted, and the man in charge stops the machinery. Telephones are then switched on at both ends, and the line wires are used to speak between the two termini. As long as the stirrup is on the wires in the Exhibition, it is perfectly safe to use the telephone, even if by some mistake the machinery at Lauffen were started whilst a person is on the telephone. The only effect in this case would be to immediately melt the fuses again, and as their replacement gives some additional trouble to the man in charge, he will in his own interest take care not to start the machinery before the appointed time.

It remains yet to describe the provision made to guard against accidental injury to life or property in case one of the line wires should break and fall to the ground, or an earth should occur on the line through some other cause. As will be seen from the sketch the common junction O of the thick wire coils of the transformer at Lauffen is joined by means of a fuse F_0 with the common junction O of the thin-wire coils.. The electrical centre of the whole system is, therefore, permanently connected to earth. Suppose now that the line wire 1 should break at any point between Lauffen and Frankfort and fall to the ground, the broken end will make earth, and the corresponding fuse F_1 in the line at Lauffen will go. Possibly the junction fuse F_0 will go. The line 1 is thus cut out. In all probability the fuse in the low-pressure circuit I will also melt; but should this not be the case, the current in this branch will be very much reduced, and set the relay R_1 in action, whereby, as already explained, the excitation is cut off, and the dangerous pressure is immediately taken off all the three line wires.

We have yet to describe the general arrangement of the circuits in the power station at Frankfort (Fig. 2). The primary and secondary of the transformers (of which only one is shown, the other being a spare transformer at present) are again earthed at their electrical centre, and the same remark holds good for the field and armature of the motor. The latter is shown diagrammatically in the same way as if it were a transformer, though this representation is not quite correct. The armature and field coils do, of course, not remain in the same relative positions to each other, but for the sake of simplicity the diagram may be accepted as sufficient for our purpose. In reality, the field revolves with a greater speed than the armature, the difference in speed or magnetic slip producing the E.M.F. in the armature. Now the torque of the motor is proportional to the strength of the field and to the armature current, which latter increases with the E.M.F., and, therefore, with the magnetic slip. If the magnetic slip were zero, that is, if the armature revolved with the same speed as the field, there would be no E.M.F. in the armature coils, and, therefore, no current and no torque. A motor of this class can, therefore, not run synchronously, but must run the slower the more the load is increased. The variation in speed between full load and no load can, however, be made as small as desired by the simple expedient of using an armature of low resistance, so that even a slip of 5 per cent. or 10 per cent. shall produce the maximum current required at maximum load. In this respect the three-phase motor is identical with an ordinary continuous current motor with constant field, since also in this case the speed of the armature decreases as the load increases. To obtain more or less uniformity of speed is, therefore, simply a question of the amount of iron and copper which the designer chooses to employ for a given output; but it should be remarked that by increasing the section of the armature conductors so as to get very little magnetic slip, there is danger of producing a machine which will not readily start at full load. The reason is obvious. A very low armature resistance means

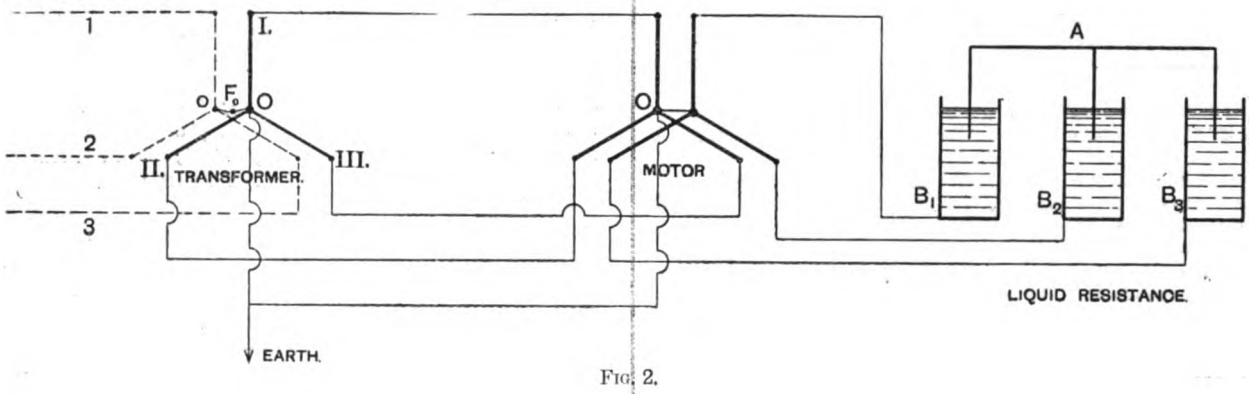

FIG. 2.

an enormous armature current at the moment of starting when the magnetic slip is 100 per cent. Now, this enormous armature current reacts very strongly on the revolving field, which is, so to speak, blown aside by the ampere turns in the armature. This may, at first sight, seem a very serious drawback to the three-phase motor, but Herr von Dobrowolsky has hit upon a very simple and ingenious remedy. Instead of short-circuiting the armature coils at starting, he inserts into each of the three branches a liquid resistance, consisting of an iron vessel filled with an alkaline solution, into which an iron plate can be dipped to a greater or lesser depth. The three vessels, B_1, B_2, B_3, are insulated from each other, but the three iron plates are joined by a metallic bridge, A. At starting, the plates are immersed only slightly, and the resistance which is thereby interposed in each of the three armature circuits prevents the creation of abnormally strong armature currents, which would otherwise blow the field aside. As the motor gathers speed the plates are more and more lowered until the whole of the liquid resistance is short-circuited, and the motor works without external waste of energy. As regards the question of efficiency, no definite data are, as yet, available, since the Commission have not yet begun to make their measurements. If we may judge from the absence of heating, vibration, noise, and the general sweetness of the running of this motor, there is every reason to hope that the efficiency will be as high as with a direct-current motor of the same size. A rough test, which the writer was permitted to make on a three-phase motor of 2 H.P., gave an efficiency of 82 per cent.

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UNITS, NEW AND OLD.

The question of units and their nomenclature will, in all probability, afford a topic for discussion, an excuse for suggestion, and a subject of controversy for many years to come. There are a good many busy people who are well content with our present supply of units; they make daily use of some of them, such as the ampere, volt, and ohm, and never even think about others, such as the dyne, the erg, and the coulomb, from one year's end to another. To some of the ultra-scientific minds there is a quasi-sacred character about the C.-G.-S. system; it appears to them that it should be accepted by that inferior animal the practical man as a revelation, and they accordingly try to trip him up if they hear him speak of an ampere-hour. If he happen to know that by an ampere-hour he means three thousand six hundred coulombs he will, perhaps, ask what could have induced the apostles of the C.-G.-S. gospel to invent such a miserable little unit. Coulombs and dynes may be suitable for gnomes and elves to use in the laboratories where glow-worms get their tails charged; but a ROTHSCHILD might as well transact his operations in cash with centime coins as an engineer measure his engine output in ergs.

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There will always be some one to suggest new units, to modify the present ones, and to coin fresh names. The amusing occupation of name-making is not confined to the christening of brand new units like barads and boles, but may be practised with the praiseworthy motive of bringing unpopular units into common use. The professor in his lonely study may contemplate a gramme moving with the velocity of a kine and delivering the blow of a bole. He hardly dare teach these things to his class; and such matters remain, like the esoteric doctrines of the Egyptian hierophants, as a subject which they may only discuss with one another. Units can acquire a vital existence only by becoming used in daily work, and they must not merely be fit for use but there must be a need for them.

An attempt was made by Prof. STROUD at the British Association this year to vitalise the dyne. The idea seems to be that it must first be multiplied until it is big enough for the practical man to recognise it as being comparable to the forces with which he is concerned, and, secondly, it must be given a name sufficiently free from pedantry. Neither dynam nor hebdomadyne have the smallest chance of success, and there is no precedent for torturing the honoured name of a distinguished man into a slang title for a mechanical unit. That has been left for electricians; slang being defined in the dictionary before us as "the jargon of some particular calling or class in society, as the slang of the theatre, of college, of sailors, &c." How few colleges of science are guiltless of contributing to such slang as this?

There has been an uneasy feeling among a few of the priesthood who look after these mysteries, that even the volt and the ampere were rather hastily chosen, and that the practical man might get along with fewer figures if these units were multiplied by ten. When professors get from five to seven months' holiday it can easily be understood that, as far as their mere duties go, they have time enough to pay attention to these matters; and such a change as this might even be rather pleasant, and would form an item to be corrected in the next edition of the text book. But the unhappy practical man, whose attendance at his office from ten to six nearly all the year round is but a portion of his work, finds the erg and dyne to be hopelessly infinitesimal, though he has never been heard to complain of the smallness of the unit of current and voltage. He may well be thankful that the Electrical Standards Committee, with all their science and lofty attitude towards him, have allowed these to pass, and have by their resolutions rendered any further change impossible.

A new and shockingly unscientific unit, the electrical horse-power, is insensibly coming into use, although no sanction has been asked from the Committee of the British Association, which is kind enough to look after these matters. The watt is a paltry little unit. Unit-making was in its infancy when Sir WILLIAM SIEMENS called this into existence. There had been a long pause, broken only by the change of the ambiguous weber into the ampere. But the watt, though popular enough in this country, is not generally accepted on the Continent, perhaps on account of its extremely foreign spelling, not a few founts of French type being destitute of the initial letter. Popular as it is, we very rarely have to deal with a single watt in practice. For most engineering purposes the sixty-fourth of an inch, being the smallest division on a rule, is the smallest length that is considered; so the watt, of which sixty-four go to a sixteen-candle lamp, is the smallest amount of power that need frequently concern the engineer. He unconsciously sins pretty often in using the watt as a unit of energy, but the priesthood never call him to account for it.

It might have been expected that as the smallest dynamo which it is worth while to build—except for amateurs to amuse themselves with—gives from one to two thousand watts, the unit of power would be found rather small. Of course the kilowatt was produced almost before the inconvenience was recognised, and a few dynamo makers wishing to appear to be up to date, timorously adopted it. It has been confidently hoped that the kilo-watt would quietly supersede "the picturesque term 'horse-power,'" as it has been called; but we see, as yet, no indication of this. It has, however, become more common of late to speak of an electrical horse-power, and the 746 seems to disconcert the practical man as little as the 112, the 2240, the 1760, or any other of those numbers which the decimalist bids him renounce, or even the 3·14159, from which there seems to be absolutely no possible escape, even by the joint action of the British Association, the Board of Trade, and the Privy Council.

REVIEWS.

Primary Batteries. By HENRY S. CARHART, Professor of Physics in the University of Michigan. (Boston: Allyn and Bacon. 1891.)

Many people, we believe, share our feeling that there is something innately immoral about "primary batteries." They are associated with so many lies and so much impudent imposture, with nonsense talked and money wasted, that the title of the present book at once conjures up a vision of wonderful secret depolarizers at so much a gallon, of valuable waste products, and of smelly offices of syndicates whose chief discovery is that a little nitric acid freshens up a bichromate battery.

Prof. Carhart does not deal with such matters, but, beginning with Volta's pile, he developes the subject of the theory and the construction of batteries, discussing the practical effects of polarization and amalgamating zincs very fully. The Bunsen cell does not hold quite so important a position as it did a few years ago, since most laboratories and lecture-rooms are provided with dynamos or storage batteries; but it is worthy of more than a single page, and some hints might be given as to securing a good contact with the carbon, and the need for taking to pieces after use. The author divides batteries into the open circuit and the closed circuit class. The former are adapted, and the latter are unfitted, for standing idle on open circuit. The distinction is worthy of consideration, but the conditions cannot be clearly defined in practice. A number of forms of the Leclanché cell are described and illustrated, several of them being unknown in this country. The Gassner and Meserole dry cells are the only two of this important class which are mentioned; and we hope that the author will turn his attention to the several very useful batteries of this kind which are now on the market. A short chapter deals briefly with standards, including various forms of Clark and Daniell cells. An interesting chapter is devoted to the testing of batteries, and contains numerous diagrams giving plotted curves of output, polarization, resistance, and recovery of voltage. One section, on the "Analysis of the Temperature Co-efficient of a Battery" has already appeared in our columns (p. 167 of the present volume of *The Electrician*). This excellent little book concludes with a chapter giving a short sketch of the thermal relations—that is, the heat evolved, the heat of combination of ions, and Helmholtz's thermo-chemical considerations.

In common with nearly all other books, too little attention is given to the actual internal resistance of the cell as a whole, of the various parts of the internal circuit, or the relation between the polarisation, internal resistance and dimensions of the elements and thickness of porous cells, and of solutions and their density. A little more exactness as to output would be useful, as when, after describing a Gethins battery, the author informs us that "three of these cells in series will keep a storage battery charged so that it will run a phonograph as much as is required

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for a private office." We gather from this that it would heat to redness quite a considerable piece of platinum wire. Sir William Thomson's Tray battery, it is said, may have an internal resistance as low as 0·2 ohm, but no quantitative information is given as to the connection between this resistance and the dimensions of the battery. We are quite aware that no other author has taken the trouble to go into this, but Prof. Carhart gives us so much that is useful in this work that we are tempted to ask for more. We notice that no reference is made to "lithanode," but though this has been talked about for some years, circulars relating to its practical use have only just been issued, and perhaps the author has done wisely in confining himself to his own experience. Another omission, justified no doubt for the same reason, is the Weymersch battery, for which the language in the opening paragraph of this review is perhaps a little too strong.

Telegraphy. By W. H. PREECE and J. SIVEWRIGHT. Ninth edition; revised and enlarged. (London: Longmans, Green and Co. 1891.)

The whole of the telegraphic communication of this country being practically in the hands of the Post Office, there is no great demand for text books on the subject of telegraphy. There is, as a matter of fact, only one book in general request—that is, the one which has reached its ninth edition, and is now before us. It is by no means a mere reprint, but has been brought thoroughly up to date by including, *e.g.*, descriptions of the Delany multiplex system and its development, and a good elementary account of telephony. The second chapter, in which the practical forms of batteries are described, is full of hints as to setting up and maintenance, but says little or nothing about the actual internal resistance, or the number of cells required on different lines in practice. We cannot find any mention of the current or the number of cells required for working the Wheatstone automatic; and though the number of cells for the Delany system is given, there is no clue to the working current. Milliamperes are still regarded as new-fangled innovations by some telegraphists. It is only a few years ago that resistances were given in miles of iron telegraph wire and voltage was measured in Daniells. Our Post Office engineers and operators are perfectly familiar with milliamperes, and it would be well to let the student know from the first the kind of currents he has to deal with. For clearness of style and completeness of description this book cannot be beaten, and in this respect we are not aware that it has a competitor.

Chapters on Electricity. An Introductory Text Book for Students in College. By SAMUEL SHELDON, Professor of Physics and Electrical Engineering, Polytechnic Institute of Brooklyn. (New York: Charles Collins.)

This rather meagre book is Part VII. of Olmstead's College Philosophy, and is "intended for use as a text-book by students in those colleges which devote but thirty or forty hours to the subject." It is open to question whether a smattering can best be obtained from the careful study of a few chapters into which the author has attempted to compress the leading principles, to the exclusion of details of apparatus or demonstrative experiments, or by a perusal of a larger and more attractive treatise which will not demand so much mental concentration.

Telephones, their Construction and Fitting. By F. C. ALLSOP. (London: E. and F. N. Spon. 1891.)

Coming most opportunely when telephones of all sorts and qualities are being at length freely sold, this book will enable anyone of ordinary intelligence to fit up ready-made instruments, and it contains sufficiently complete and well-illustrated descriptions of them to allow many of them to be made at home.

Thoroughly practical directions are given for running overhead wires and leading in; but the chapter on connecting up is, if anything, rather alarming, since the author discusses some twenty different arrangements with as many diagrams. A brief chapter on small exchanges for hotels, &c., and one on testing conclude the book. The last section describes very clearly and with full detail a number of common faults, and gives simple directions for locating the trouble and remedying it.

An Introduction to the Mathematical Theory of Electricity and Magnetism. By W. T. A. EMTAGE, Examiner in the School of Natural Science, Oxford. (Clarendon Press. 1891.)

This text-book aims at being "complete in itself, and may be read without previous knowledge of the subject." We do not know to whom it is addressed, but we suppose that as a science school is springing up at Oxford, text-books must be written by the examiners as elsewhere. The treatment of the subject is purely academical; it goes over a good deal of the ground covered by Maxwell in an elementary style, considerably too stiff for the ordinary engineer, but yet offering few apparent advantages to the mathematical student. The real want of to-day is some explanation of the more difficult branches of electrical science, treated, perhaps, in a mathematical manner, but with the view of teaching something or of elucidating something, and not as a mere branch of mixed mathematics. It is possible that such a book as this may interest some mathematical student who, having thus had his attention turned to electrical science, might eventually assist in developing it. If this should happen, the book will, in an indirect manner, prove of some use. Without wishing to detract in any way from the educational value of the book, we may mention the fact that the alternate current transformer is not alluded to in its pages, lest students of this difficult branch of electrical science may turn to them hoping to find some help.

THE ETHER AS A POWER TRANSMITTER.

BY S. TOLVER PRESTON.

It may be of interest to view the ether in the aspect of a transmitter of power. We know that a belt will convey more power by the same stress, the greater the velocity at which it runs. So now that the ether in the case of our batteries and dynamo circuits is recognised to be a power conveyer, or to play the function of a belt or belts, we may comment on its adaptation for that object as a mere question of mechanics. The ether conveys power at the velocity of a well-known speed unit, viz, that of light. So that the ether may be very well compared to a belt moving at this speed when carrying over energy.

It may be a fact worth noticing (since heat waves and electric waves are now recognised as identical) that singling out any column of ether, say, one square foot in sectional area resting on the sun's surface normally, then, as a truth, it carries off 7,000 H.P. continuously. This is a fact recognised to be grounded on the firm basis of experiment. It is easily computed by remembering that the energy of the heat waves next the solar surface is 46,000 times their energy (measurable) at the earth's surface. The 7,000 H.P. equals 1,720 foot tons of energy propelled through the ether column a foot square per second; and in carrying off this energy, no more than 27 foot grains of energy is traversing or contained in any prismatic section of the transmitting ether column a foot long and a foot in area at any given instant. This is evidently because the column transmits the energy so rapidly that it does not require to carry much all at once. It is somewhat comparable to a belt going at the velocity of light, which in conveying 7,000 H.P. would only be under a stress of 27 grains; this being cursorily mentioned in a previous article (*The Electrician*, August 14th). The realisation of facts of the character above cited may contribute to make one regard the ether as a highly practical mechanism, rather than as the vague, purposeless sort of existence some are liable to consider it, unless the meaning of the above *rôle* played by the ether be grasped as a true physical conception.

It may be difficult to imagine that there should be no back pressure or reaction of the ether against the solar surface in carrying off such an enormous total of energy, even if the impulses be mainly transverse; and it would seem probable that there is some reaction, as we, perhaps, never deal with radiant energy on a scale sufficient to measure any. Perhaps the only ether structure where an entire absence of reaction might be imagined is one partly based on an idea of mine relative to the

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mechanism of gravity. Maxwell, in reference thereto, suggested (perhaps more as an interesting mechanical point than with a serious view of the existence of his idea in nature) that "It is easy to see that we might form a theory in which the molecules [of ether] never interfere with each other's motion of translation, but travel in all directions with the velocity of light; and if we further suppose that vibrating bodies have the power of impressing on these molecules [of ether] some vector property (such as rotation about an axis) which does not interfere with their motion of translation, and which is then carried along by the molecules, and if the alternation of the average value of this vector for all the molecules within an element of volume be the process which we call light, then the equations which express this average will be of the same form as that which expresses the displacement in the ordinary theory" ("Encyc. Brit.," 1878, article "Ether," p. 572, &c.)

There is an obvious difficulty about the molecules, or rather ether atoms *never* interfering with each other's motion of translation, but it may be diminished to any extent by imagining the atoms adequately small. Might I venture to ask here if vortex atoms, which, it seems, have a natural proper motion, would not tend to acquire all the same velocity, if the path were adequately long, and to have a velocity equal to that of light under suitable conditions? Here it may form at least a noteworthy point of mechanics to imagine how such ether atoms could, in passing through the open structure of the vibrating molecules of gross matter, receives *transverse* impulses, without the slightest back reaction or rear thrust against the body emitting* the light. This, I must confess, is the only way in which the idea of a total absence of back stress in the conveying away of energy can present itself to my mind. The above suggestion of Maxwell may be viewed at any rate as a thoroughly clear mechanical conception.

THE DETERMINATION OF CURRENTS IN ABSOLUTE ELECTRO-MAGNETIC MEASURE.

BY G. F. C. SEARLE, M.A.

(*Continued from page 527*).

§ 9. **Stokes's Theorem.**—We can now proceed with Prof. Stokes's proposition. This may be stated as follows: Take any closed surface S (Fig. 7) in a magnetic field. Take a small area, α, at P and let F be the magnetic force at P resolved in the direction of the outward normal to the surface. Take each

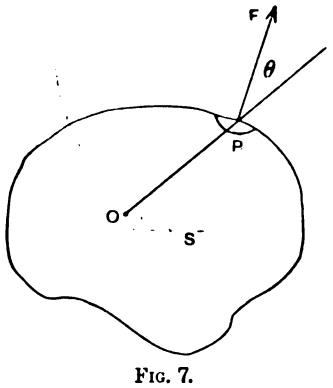

Fig. 7.

element of the surface and find the product $F\alpha$ for each, add all these products together, and let $\Sigma F\alpha$ denote the sum. The proposition we have to prove is that $\Sigma F\alpha = 4\pi$ + (quantity of north magnetism inside).

Take, first, the case of a single north pole of strength m at any point O inside the surface. Let OP produced make an angle θ with the outward normal, and let $OP = r$. Then the magnetic force at P is $\frac{m}{r^2}$. Resolved along the outward normal this gives $F = \frac{m\cos\theta}{r^2}$. The contribution of the small area α at P to the sum $\Sigma F\alpha$ is, accordingly, $\frac{m\cos\theta \times \alpha}{r^2}$. But $\frac{\alpha\cos\theta}{r^2}$ = solid angle subtended by α at O. Let this small solid angle be ω. Then the contribution from α to the sum is $m\omega$. Adding all the contributions together we have $\Sigma F\alpha = m \times$ (whole solid angle subtended at O). When O is inside the surface the solid angle $= 4\pi$, so that we have for this case $\Sigma F\alpha = 4\pi m$. If we had taken O outside the surface, the solid angle would have been zero, and in this case $\Sigma F\alpha = 0$. We may accordingly write quite generally $\Sigma F\alpha = 4\pi \times$ (strength of pole inside surface). If there are any number of poles, some inside and some outside the surface, the above result applies to each one, and hence by addition we obtain the result $\Sigma F\alpha = 4\pi \times$ (total amount of north magnetism inside the surface). A south pole must, of course, be counted as a negative north one.

§ 10. **Tubes of Force.**—Now (Fig. 8) take a small area α at A perpendicular to the direction of the field at A, and draw lines of force from all points of its boundary. Let the tube so formed be cut at A′ by another area α' perpendicular to the lines of force at A′. We suppose that there are no magnetic substances inside the part of the tube included between A and A′. Let F, F′ be the magnetic forces at A and A′ respectively. Since there are no poles inside the surface formed by the sides of the tube and the two ends A, A′, we have, by applying Prof. Stokes's theorem,

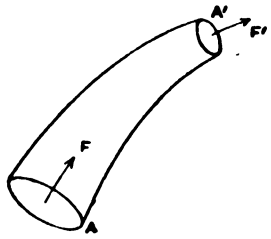

Fig. 8.

$\Sigma F\alpha = 0$. But since the magnetic force at any point on the side of the tube is parallel to the side of the tube, the sides contribute nothing to the sum. The contribution from A′ is $F'\alpha'$, and that from A is $-F\alpha$. Hence $F'\alpha' - F\alpha = 0$, or $F\alpha = F'\alpha'$. Thus the product of the magnetic force and the cross-section of any very small tube of force is constant for all points along the tube.

Now let us draw a number of lines of force through the area A, arranging them so that there are F lines of force passing through each square centimetre of the area A. The whole number passing through A is therefore $F\alpha$. These lines run along inside the tube, emerging again at A′, $F\alpha$ lines of force passing through an area α'. Hence the lines per square centimetre passing through A′ is $\frac{F\alpha}{\alpha'}$. But by Stokes's theorem $F\alpha = F'\alpha'$, and therefore $\frac{F\alpha}{\alpha'} = F'$. Thus the number of lines per square centimetre passing through the area at A′ = magnetic force at A′. Thus, if we take any surface so that the magnetic force is everywhere normal to it, and from this surface draw lines of force so that the number of lines per square centimetre passing through this surface anywhere is equal to the magnetic force there, then this system of lines of force will represent completely at all points of the field both the direction and magnitude of the magnetic force—the direction being indicated by the direction of the lines, and the magnitude by the number of lines passing through a square centimetre placed perpendicular to the lines.

We have just seen that when the strength of the field is F the number of lines of force through a square centimetre, placed perpendicular to the lines, is F. Hence, the area occupied by

* Of course, it will be seen that this is not an emission theory of light. Particles are not ejected from the luminous body under this theory. It is an undulatory theory where the mechanism of light is always in motion—streams of particles moving equally in all directions through space, and acting as "vectors" to carry the luminous energy off. Here no other than transverse impulses are mechanically possible.

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each line is $\frac{1}{F}$ per square cm. We obtain, perhaps, a better idea of the state of the field if we suppose it filled with *tubes of force*, the cross section of each one at any point where the magnetic force is F, being $\frac{1}{F}$ square cm. We may, if we like, regard the *lines of force* as core lines of the tubes of force. For most purposes, we may use either the lines or the tubes of force indifferently. When we consider how the energy is stored in the magnetic field, we shall find it better to use the tubes of force.

§ 11. **Number of Lines from a Magnetic Pole.**—Take a single pole of strength m, and about it as centre describe a sphere of radius r. At any point on this sphere the magnetic force due to m is $\frac{m}{r^2}$. Hence, according to the plan which we have adopted for drawing lines of force, there are $\frac{m}{r^2}$ lines of force passing out through each square centimetre of the surface. The whole surface of the sphere is $4\pi r^2$, so that the whole number of lines passing out through the sphere, or, what is the same thing, the number of lines proceeding from the pole is $4\pi m$, independent, as it ought to be, of the size of the sphere. Thus, from every pole of strength m there proceed $4\pi m$ lines of force. If we take any solid angle ω with its vertex at m, then, since the lines proceed equally in all directions, the number of lines passing out through the solid angle is $m\omega$. If we have a magnet each of whose poles is of strength m, there will be $4\pi m$ lines of force proceeding from the north pole, and as many converging into the south pole. The lines

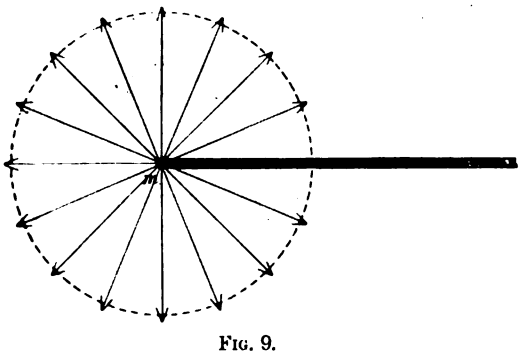

Fig. 9.

complete their course by running back again through the iron to the north pole. When in the iron, they have to be drawn so as to represent not the magnetic force but the magnetic induction. In air the magnetic induction is the same as the magnetic force, but in iron the two are very different, but as we are only going to deal with the action of currents in air, we have no need to go into the question of the difference between the magnetic force and the magnetic induction in iron. We shall, however, use the term *magnetic induction*, even when we are dealing with air, since our results would then be true in case the air were replaced by a magnetic medium; on other occasions, when the result depends upon the magnetic force, whether in iron or air, we shall use the term *magnetic force*. The magnetic induction in passing from iron to air is continuous, *i.e.*, does not suffer any sudden change in its value, while the magnetic force experiences a sudden alteration in its amount. In isotropic media the magnetic induction and the magnetic force are everywhere both in the same direction. We ought now to restate the proposition of the present section as follows. From a pole of a magnet of strength m (Fig. 9) there proceed $4\pi m$ lines of induction into the air, and $4\pi m$ lines of induction run through the iron up to the pole. In fact, the relation of the magnetic induction in the air to that in the iron is very much like that of the spray from a fine rose to the stream of water flowing to it from the supply pipe; the law of continuity applies in both cases. The tubes of induction are very thin in the iron, and spread out into much fatter tubes in the air.

§ 12. **Superposition and Resolution of Magnetic Fields.**—It is often convenient to resolve the magnetic force (or induction) into components in any chosen directions. We may suppose that each of these component fields is represented by the appropriate distribution of the tubes of magnetic induction in its own direction. But we must only make use of this representation in a perfectly uniform field, or in a part of the field so small that we may consider it uniform throughout that part. The reason for this is that except in a perfectly uniform field the tubes drawn to represent the field in any given direction would not be continuous, *i.e.*, they would have to start with *ends* in order to represent the magnitude everywhere of the component of the induction in their direction. A tube of induction is always closed upon itself so that it cannot do this, and our representation would fail. But in a very small part of the field we may use the principle indicated above with safety.

§ 13. **Magnetic Potential.**—The work, measured in ergs, expended upon a unit north pole in bringing it from an infinite distance to any point of the magnetic field is called the *magnetic potential* at that point. If infinity is too great a strain

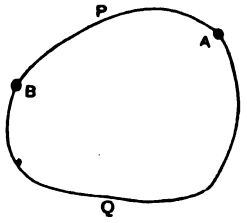

Fig. 10.

upon our imagination, we may say that the potential at any point is the work done in bringing a unit pole to that point from a very distant region where the action of the system producing the magnetic field is inappreciable. This is the same as the potential energy of the unit pole when at the chosen point. One or two very important propositions concerning the potential are very easily established.

(1.) The work done in taking a unit pole from A to B (Fig. 10) does not depend upon the path taken; for if the work were different for the two paths, A P B, A Q B, we could, by making the pole go round the complete path, A P B Q, in the right direction, obtain as much work from the system as we please by making the pole go round its path a sufficient number of times; this, unless some energy has been supplied from other sources, is contrary to the principle of the conservation of energy, and must be considered impossible. Thus the work done in going from A to B, or the difference of potential between A and B, is the same by whatever path we go.

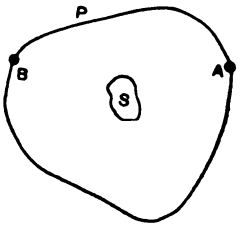

Fig. 11.

There is, however, a very important exception to the above statement. If there is an electric current flowing along a conductor, of which S (Fig. 11) is a section, then, unless we can transform the path A Q B into the path A P B, without making the moving line cut through the conductor S, the difference of magnetic potential between A and B is different according as we suppose the unit pole to be taken along the path A P B or by the path A Q B. If we can transform the one path into the other without making the moving line cut through S, then the proposition stated in (1) holds good. But if the two paths cannot be transformed one into the other without cutting through the conductor, then there is a definite difference in the work done in taking the pole from A to B by the one path or the other. As we shall see later, this difference is equal to $4\pi C$, where C is the electric current through the conductor S. It might seem at first sight as if this statement were at variance with the principle of the conservation of energy, but it is not

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so, for energy is either supplied or absorbed by the system of wires and batteries which is conveying and producing the current. For the present we shall not take this exceptional case into consideration.

(2.) If we know the value of the potential V at every point of space, we can at once find the force in any desired direction experienced by our unit pole when placed at any point. Take two points, P Q (Fig. 12), close together, and let the line joining them be the direction in which we wish to find the force. Let V_P, V_Q be the potentials at P and Q respectively, and suppose that the potential at Q has a greater value than the potential at P, so that we have to expend work upon the unit pole in bringing it from P to Q; thus, the force exerted by the

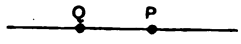

Fig. 12.

magnetic system upon the unit pole along the line P Q is in the direction Q to P. Since we have taken P and Q very close together, we may consider that the force experienced by the unit pole is uniform over the small space, P Q. Let F dynes be the force on the pole in the direction Q to P. In moving the pole from P to Q we must do F × P Q ergs of work. But we have another expression for the work spent on the pole, viz., $V_Q - V_P$.

$$\therefore V_Q - V_P = F \times P\,Q,$$

and therefore $$F = \frac{V_Q - V_P}{P\,Q} = -\frac{V_P - V_Q}{P\,Q}.$$

Thus we see that the force in any direction experienced by the unit pole is equal to − (the rate of increase of the potential in that direction). We can express this result in the language of the differential calculus as follows:—Let S (Fig. 13) be the

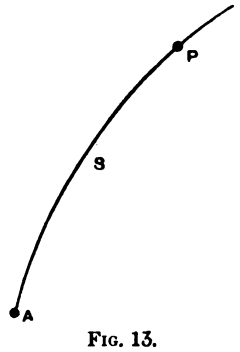

Fig. 13.

length of a curve A P measured from a fixed point A. Then the force experienced by the unit pole placed at P along the tangent to the curve at P in the direction in which S increases, or, in other words, the magnetic force in that direction is $F = -\frac{dv}{ds}$.

(To be continued.)

COPPER AND ALUMINIUM.

Repeated references have been made for the last year or two in the American electrical and engineering journals to "tempered copper." We have been at some pains to discover what is meant by this, and have inquired from copper manufacturers in this country and from our American correspondents. We have been inundated with testimonials and eulogistic accounts of its behaviour; but the only figures that have reached us give a tensile strength of 30,400 pounds per square inch, which, so far from being extraordinary, is about the inferior limit of good sheet, which should show 30,000 to 33,000, while bolts stand 30 per cent. more, and wire twice as much. This peculiar kind of copper is supposed to be particularly adapted for bearings and commutators; but it is not known in this country, and we have lost all interest in it since we have learned that the preparation is a secret. We have seen a chemical analysis from the Franklin Institute which revealed nothing, and which gave neither the amount of oxygen or carbon, or the specific gravity. It is doubtful whether the minute traces of oxygen and carbon which exercise so great an effect on the physical properties of copper can be estimated with any degree of accuracy; and it is to be hoped that some such methods as those which Mr. H. Tomlinson has employed to investigate the influence of stress and strain on metals by means of magnetic cycles may be applied to those cases where chemistry fails to give any useful information.

The alloys of copper are at present the most important that we possess, and the time when they will be supplanted by mixtures in which aluminium exists in larger proportion seems to be yet far distant. Elsewhere will be found two metallurgical articles bearing on these matters. One on the annealing of copper gives an account of some of the physical changes which take place during manufacture, and those which may be produced by subsequent treatment. There is no question but that the progress of electrical engineering has had a very marked effect upon the copper industry, though the probability of any considerable increase in demand, owing to the spread of electric lighting, is not great. The actual quantity already laid in our streets and hung over our heads is, after all, but a small part of that which is used for sheathing of ships, or for brass founding, every year. By the demand of the electrical trades, copper manufacturers have been made aware of the impurities with which crude copper is contaminated, and they have been compelled to change their processes and to modify their treatment, both of the ore and of the fine metal. The care which has been exercised in the production of high-conductivity copper, a care necessitated by the requirements of tests of a totally different character to those which were considered sufficient some twelve years ago, have contributed in no small degree to the improved mechanical qualities of the refined material. The excellent qualities of electro-deposited copper, and the certainty that no minute and unsuspected traces of arsenic or antimony could remain, led to the recovery of the metal from sources which it had not been worth while to work, and a secondary result of no small importance has been the recovery of gold and silver which could not otherwise have been separated. The latest modification of this process is being shown by Messrs Siemens and Halske at the Frankfort Exhibition, the novelty being the use of a solution of metallic salt other than copper, to assist in the extraction from the ore. Iron is used for this purpose, and it exists in the solution alternately as ferrous sulphate and as ferric sulphate. On combining with the copper in the ore, a reduction of the ferrous salt takes place, and when the copper is deposited electrolytically the iron sulphate becomes oxidized and may be used again without any consumption or waste. There is, therefore, no attempt to use the copper ore as an anode, but the extraction and the deposition are conducted as two distinct processes.

In the manufacture of electrical conductors it is sufficient, as a rule, to say that the purer the copper is the better, though silicium bronze and other alloys of an analogous character have their important uses when low resistance is not of the first importance. But for the mechanical engineer, the peculiar physical properties of copper deserve more attention than has been given to them, and almost as many varieties of copper are to be had as of iron and steel; nor are the causes so dissimilar as the widely different chemical characteristics of the elements suggest. It might be imagined that since iron is attacked by the oxygen of the atmosphere so much more readily than copper, which shows but little affinity until it is heated considerably, it would part with its oxygen during manufacture as easily as does iron in the blast furnace. However, not only is oxygen retained, but on re-melting it will, like silver, absorb oxygen, to give it out, partially, during solidification. Copper has two states of hardness and brittleness, as far as oxygen is concerned, the one containing too much, and the other too little, and both of these have been avoided with care by manufacturers. But so tenacious and ductile a metal cannot pass to the brittle stage without passing through various degrees in which it acquires hardness, and before brittleness is reached it must pass through

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a tough condition; and it is probable that if some of these intermediate stages can with certainty be produced, we may have in practically pure copper a material which offers very considerable advantages to the engineer. For bearings and commutator bars and other purposes where tensile strength is either unnecessary or can be provided by the surrounding parts, the toughening would be highly desirable. The presence of carbon in minute quantities acts on copper as it does on iron, but the proportion, which varies in steel from 0·6 to 1·8 per cent., is difficult enough to estimate by analysis. In copper, however, even 0·2 per cent. of carbon will render it almost useless, while that amount is always to be found in good bar-iron. The difficulties of producing a steeled copper present, therefore, some difficulties, but the result would be well worth attaining. Some such modification has, probably, been arrived at in the "tempered copper" to which we have alluded; and while we would always respect a patent, we have no such feelings for a trade secret; and, always supposing that the article is really better than a mild bronze, we hope that the process will soon be discovered by our copper manufacturers, if, indeed, it is not the one described in the article by Mr. Cummings which we reprint in another column.

Aluminium, before it was produced in a nearly pure state, was said to be of immense importance for alloying with copper; and the gold-like bronze which has for so many years been used for little else than pencil-cases and tawdry watch chains, was expected to take a prominent place in engineering and many other industries. We have ourselves had some experience of it for small castings, where it was expected that the lightness would be advantageous, but they were so spongy, and in some cases so rotten as to be useless. In instrument-making, solder and paint cannot be used as freely as in engine-building for stopping blow-holes and bubbles, and although these do not occur so frequently in heavier pieces, the difficulty of casting and of soldering this alloy places it at a considerable disadvantage. As far as mere lightness goes, the extreme stiffness of phosphor bronze affords to a skilful designer the opportunity of producing a very light casting by careful attention to the mechanical requirements of the case. Aluminium is analogous to copper in being very soft in its pure state, but becoming extremely hard and brittle when very slightly alloyed with other elements; and, on the other hand, it resembles iron in forming a series of compounds when combined with carbon and silicon, the different varieties exhibiting the well-known grey, granular, brittle, and crystalline characteristics of cast iron. The production of nearly pure aluminium created another stir, unconnected with the mere price, but founded on the attractive properties of the metal. According to enthusiasts there was nothing that it would not do; and although after many months there is little to be seen of it, it is probable that some more good will come of it than the production of a few enormous dynamos, which were destined to be employed in turning out tons of the metal.

SCOTT-SISLING SYSTEM FOR SMALL ELECTRIC LIGHT PLANT.

Private lighting generally involves the use of accumulators, and to charge these the dynamo voltage must, of course, be raised some 25 per cent. above the lamp voltage. In many cases this is inconvenient and wasteful, as the dynamo must be "run up" to this increased voltage, although only a portion of the current generated may be used for charging, the remainder being required for the lamps at the normal voltage.

We illustrate an arrangement devised by Messrs. W. B. Sisling and W. H. Scott having several features which ought to prove advantageous in a private installation. The arrangement may be described as a compound dynamo, with a small supplementary winding on its armature connected to an extra commutator, which gives a voltage usually about one-quarter of that given by the main commutator. A branch is taken from the main circuit, and connected so that the extra commutator raises its voltage by about 25 per cent. This forms the charging circuit. The dynamo can thus be driven at constant speed, and will supply constant voltage to the lamps from its main circuit, undisturbed by the increasing voltage from the cells during charging.

The whole of the cells can be charged by a large current supplied to the lamps at the same time, as this does not pass through the regulating cells. The charging can, therefore, be accomplished during the hours of lighting, instead of the dynamo having to be run specially during the day.

The diagram shows the general arrangement. The dynamo armature has a main commutator M, and an extra commutator N. These two commutators are connected in series, either directly or through the dynamo series winding W. The switchboard contains two switches, viz., the dynamo switch D,

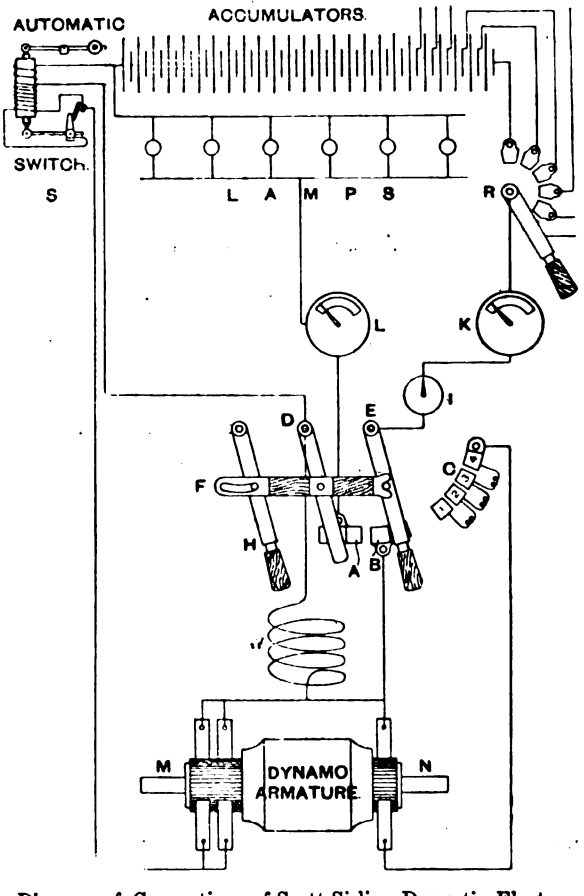

Diagram of Connections of Scott-Sisling Domestic Electric Lighting Plant.

which connects the dynamo to the lamps and the accumulator switch E, which connects the accumulators in either of three different ways, viz.:—

A to the lamps alone, or
B to the lamps and dynamo, or
C to the charging circuit.

These two switches are of the lever pattern, and are interlocked by the thrust rod F. The handle H acts on the thrust rod so that it can only put the dynamo switch "on." To take it "off" the accumulator switch must be moved so that the accumulators are connected to the lamps alone.

When the dynamo switch is put "on" the thrust rod moves the accumulator switch from A to B, thus connecting the accumulators to the dynamo in such a way that they are in readiness to assist the dynamo in supplying current to the lamps, without risk of weakening or reversing its magnetism.

If the dynamo does not need assistance and spare power is available the accumulator switch may be moved further from B to C, when the dynamo will begin to charge the cells by means of its extra commutator N, without interfering with the constant voltage which is supplied to the lamps from its main commutator M. An index I shows whether the accumulators

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are being charged or discharged, whilst an ammeter K indicates the *amount* of the charging or discharging current. A second ammeter L shows the current taken by the lamps. A pilot lamp on the switchboard lights when the dynamo starts up.

An automatic switch S, having shunt and series coils, may be used to disconnect the dynamo when its speed slackens, and will connect it again when the proper speed is recovered.

This switch consists of a solenoid having two windings. One is of thick wires or copper strip connecting the dynamo to the terminal common to the lamps and cells. The other winding is of fine wire, and forms a shunt circuit across the main terminals of the dynamo. An iron core is supported in the interior of this solenoid in such a way that when the dynamo gives its normal voltage, the iron core is drawn upwards into the solenoid, closing the switch. If now the current flows in the right direction to the lamps or cells, the core will be more strongly drawn up into the solenoid, thus increasing the pressure on the switch contact, which is a stencil copper brush. If, however, the voltage of the dynamo decreases and current flows from the cells in the wrong direction, the effect of the shunt winding is partially neutralised, and the core falls, thus opening the switch.

By means of this arrangement, the manipulation is made simple, and the charging current can be adjusted to form a complementary load, thus working the plant at its maximum efficiency, and shortening the hours of running.

The arrangement is in use in some private installations, the latest being one erected at Brandon Park, Suffolk, which is driven by an oil engine, giving 11 B.H.P. The engine is started by the accumulators, and these also work the coil which ignites each charge in the engine cylinder. The whole arrangement works satisfactorily, and without specially skilled attention, which is an important matter for country houses.

ELECTRIC MINING-MACHINERY, WITH SPECIAL REFERENCE TO THE APPLICATION OF ELECTRICITY TO COAL-CUTTING, PUMPING, AND ROCK-DRILLING.*

BY LLEWELYN B. ATKINSON AND CLAUDE W. ATKINSON, ASSOC. MM. INST. C.E.

The employment of electricity in mines for pumping, hauling and coal-cutting, is a subject which has already received some attention in Papers read at the meetings of the more strictly mining institutions. The authors have been, during the last four years, constantly connected with the applications of electricity to mining, and have spent a considerable amount of time underground, both in making experiments, and in teaching those who would have to take charge of the electrical machinery. They propose in the present Paper to show in what way the conditions of mining work differ from those of other industries, and how the problem has been dealt with, illustrating the subject by describing some of the machinery now in actual use.

The principal uses to which electrical power is likely to be put in coal and metalliferous mines, and in quarries, are the driving of pumps, of hauling and underground winding-machines, of coal-cutting machines, of drilling-machines, both rotary and percussive, and in certain cases of fans for subsidiary ventilating purposes. It will be unnecessary here to dwell at any great length on the question of the relative merits of different methods of transmitting power in mines, practical experience having shown that compressed-air is almost the only rival to electricity, although in particular instances other systems are still in use for certain purposes. Compressed air has one advantage, on which much stress has been laid, namely, that the exhaust product is in itself a valuable assistance to ventilation; but from circumstances that will presently be described, it would appear that the method of ventilating a mine by first compressing air, transmitting it under pressure, and then expanding it, is the most costly that can be devised. If power must be spent in ventilation, the best way to do it is to deliver a given volume of air, with the proper difference of pressure between the intake and the upcast. In using compressed air, in order to keep the machinery as small as possible, and at the same time to limit the expense of the piping, it is necessary to work at as high a pressure as is feasible. On the other hand, increase of pressure, which in a steam engine conduces to greater economy and efficiency, is, in the case of compressed air, the one item which reduces the efficiency.

The following table* gives the result of experiments made some years ago by Messrs. J. Fowler and Co., of Leeds, who have had considerable experience with air compressors.

Gross Efficiency of Compressed Air in the Transmission of Power.

Air-pressure. lbs.	Efficiency = Brake H.P. of Motor. / I. H.P. of Compressing Engine. Per cent.
40·0	25·8
34·0	27·1
28·5	28·5
24·0	34·2
19·0	45·8

The above results are borne out by the experiments made more recently by Prof. A. B. W. Kennedy, F.R.S., M. Inst. C.E., on the transmission of power by compressed air in Paris on the system introduced by Mr. Popp. These experiments show that the brake H.P. of the motor (10 H.P.) is 31 per cent. of that of the engine driving the air-compressor if the air is not heated before it is used in the motor. If the air is heated and expanded before passing into the motor this efficiency is increased to 45 per cent. In mining work it is generally difficult to do this, and consequently engineers are content if they can obtain the lower result.

The great advantage of heating and expanding the air before passing it into the cylinder was so far realised by Mr. Frederick Hurd, in 1872, that he devised an arrangement for placing a heating apparatus inside the valve-chest, in which the oxygen for the combustion of the fuel (a mixture of coke and scrap iron) was supplied by the air working the motor. By this means the possibility of exploding fire-damp is completely overcome, and the formation of ice is avoided.

In practice 40lb. or 50lb. is about the pressure now adopted for working compressed-air machinery, although in the case of rock-drills, where lightness, portability of the machines, and smallness of the connecting hose, are of greater importance than efficiency, 70 to 90lb. per square inch is frequently used. The final result, however, of experiments at these pressures, agrees with that already given, namely, that it is impossible with compressed air to transmit to the distant motor more than from 20 to 30 per cent. of the power expended in the engines, and probably, taking due account of the friction and loss in the piping, which, however, is not often excessive, the average efficiency of compressed air as applied to mining work would be below 20 per cent. In the case of electrical transmission of energy, except when distributed into very small units, there is little difficulty in obtaining 50 per cent. of the power expended in the engine, and there are cases in which no less than 75 per cent. is transmitted without any extraordinary precautions being adopted.

These figures are frequently contradicted by the advocates of compressed air, but after the precise particulars which have been published of experiments with electricity, and in view of the scanty information obtainable as to actual trials of compressed air, the onus lies with its advocates to show that the results which can be obtained in regular working by this method exceed those already given. In addition to this lower efficiency, which means not only a greater expenditure of coal, but also a large increase in the dimensions of the engine, and consequently in the price of the generating plant, there is the cost of laying and maintaining the connecting pipes. To make the matter clearer, a simple case has been chosen, and Table II. prepared, showing the comparative economy of these two methods of transmitting power.

Table II.

System.	B. H.P. of steam engine.	B. H. P. of motor.	Distance from engine to motor in yards.	Size of cable or pipe.	Price of engine and dynamo or compressor.	Price of cable or pipe.	Price of motor.	Total cost of plant, without erection.	Efficiency.
				Ins.	£	£	£	£	%
Electric	15·4	10	2,000	$\frac{7}{16}$	210	192	95	497	95
Compressed air	33·3	10	2,000	4	130	700	63	893	30

It must be borne in mind that the size of the cable plays a large part in determining the efficiency of the electric transmission of power. In the case of steam, compressed air, or hydraulic transmission, the losses in the pipes are frequently neglected, as they are usually small. This cannot be done with electrical plant, first, because the cost of the copper conductors forms a considerable item in the whole, and it is therefore desirable to have them as small as possible under the particular circumstances of each case, and, secondly, because, unless the cables are proportioned to the

* Abstract of a Paper read before the Institution of Civil Engineers.

* "On Compressed Air Machinery for Underground Haulage." By Mr. William Daniel. *Proceedings* of the Institution of Mechanical Engineers 1874, p. 210.

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Table I.

Size of cable.	Brake H.P. of engines	H.P. lost in dynamo and belting.	Per cent. of total H.P.	H.P. given out by dynamos.	Volts at dynamos.	Volts at motors.	Distance in yards dynamos-motors.	H.P. lost in cables.	Per cent. of total H.P.	H.P. put into motor.	H.P. lost in motor.	Per cent. of total H.P.	H.P. lost in pipes.	Per cent. of total H.P.	H.P. absorbed in friction in pump and gearing.	Per cent. of total H.P.	Useful work done in raising water.	Per cent. of total H.P.
2. 19/12	200	20·0	10	180·0	670	550	3,800	32·0	16·0	148	15	7·5	16	8·0	22	11·0	95·2	47·8
2. 19/14	224	23·0	10	201·0	750	550	3,800	53·0	23·5	148	15	6·7	16	7·1	22	9·7	95·2	42·7
2. 19/14	256	25·0	10	231·0	860	550	3,800	83·0	32·5	148	15	5·8	16	6·2	22	8·5	95·2	37·1
2. 19/14	192	19·0	10	173·0	644	550	1,800	25·2	13·1	148	15	7·8	16	8·0	22	11·0	95·2	49·6
2. 19/16	209	21·0	10	188·0	698	550	1,800	40·0	19·0	148	15	7·2	16	7·6	22	10·6	95·2	45·6
2. 19/17	216	22·0	10	196·0	730	550	1,800	45·0	22·0	148	15	6·8	16	7·4	22	10·2	95·2	44·0
1. 19/14	72	7·0	10	65 0	674	550	3,800	12·0	15·6	53	8	11·2	3	4·2	13	18·0	29·1	40·5
1. 19/16	83	8·3	10	74·6	774	550	3,800	21·6	25·8	53	8	9·6	3	3·6	13	15·5	29·1	35·0
1. 19/14	67	7·0	10	60·0	618	550	1,800	6·6	9·8	53	8	12·0	3	4·5	13	19·3	29·1	43·5
1. 19/16	70	7·0	10	63 2	656	550	1,800	10·2	14·6	53	8	11·5	3	4·3	13	18·5	29·1	41·6
1. 19/17	73	7·3	10	65·6	680	550	1,800	12·6	17·2	53	8	11·0	3	4·2	13	17·8	29·1	40·0

power to be transmitted, they may become heated and damaged by the current passing through them.

In dealing with dip-draining pumps the authors have given a table showing the loss of power in the cable in two particular cases, with small machines; but they think that a similar table dealing with large machinery and varying sizes of cable may be of interest. They have, therefore, in Table I., given the losses in each part of an electrical pumping system, first, with a pump delivering 350 gallons per minute against a vertical lift of 900ft. and a pipe line 1,800 yards long of 6in. pipes, and secondly, with a similar pump delivering 200 gallons per minute to a height of 480ft. through the same pipe line. It will be seen that an efficiency of 67 per cent. can be readily obtained even when transmitting nearly 100 H.P. to a distance of more than 2 miles, and without any attempt being made to get specially good results, the whole plant being such as can be worked by unskilled men.

The results given, are, it is true, now recognised to a large extent as being, in the abstract, correct statements of the facts; but in the minds of the owners and managers of collieries and mines, there still exists a doubt as to when they are justified in adopting the use of electricity. One of the most important points which has been raised in this connection, and which was brought very strongly to the front in the discussion on a Paper by Mr. Blake Walker,* read at a meeting of the Midland Institute of Mining Engineers, is the question "of the safety, or otherwise, of an electric motor in a coal-mine, in view of the fact of the explosive nature of the gases existing in some parts of most mines."

The problem resolves itself into two parts—First: Will a motor, working under ordinary and satisfactory conditions, be likely to cause an explosion, assuming that it is placed in the positions where motive power is usually required in mines? Secondly: Is it possible under what may be termed extraordinary, but perfectly realisable conditions, to produce an explosion under similar circumstances? A variety of opinions on the subject have been given, and some experiments have been tried bearing upon it, and the authors consider that the following may be taken to be a correct summary of the results obtained.

In the case of an ordinary motor working up to, say, 500 volts, having the brushes properly adjusted upon the commutator, no sparking can be perceived, but if from wear of the contacts during long runs, or variation in the load, slight sparking should occur, it is produced in contact with large masses of a highly conducting metal (copper), with the result that the rise of temperature is not sufficient to fire explosive mixtures of coal-gas and air, or ordinary marsh-gas and air. The temperatures required to explode these gases at ordinary pressures may be taken to be, for a mixture of 1 volume of coal-gas, with 5 volumes of air, or for a mixture of 1 volume of marsh-gas with 9·4 volumes of air, from 900° to 1,100°C.

Copper combines with oxygen in air so as to produce oxide of copper at about 700°C., and as under normal conditions the formation of this oxide is not observed, either on the collector or on the point of the brush, this fact may be taken as further evidence that the temperature there existing is not sufficient to fire an inflammable mixture of gases. It may be said, then, that under normal conditions, an electric motor is not a dangerous machine to use even in an atmosphere charged with considerable quantities of explosive gases; but having shown this, it may be admitted that supposing a brush, for example, is worn so far that it ceases to be in contact with the commutator, or supposing it to become seriously displaced from its proper position, an amount of sparking may ensue, which will cause a temperature sufficiently high to oxidize the copper of the brushes, and farther, to ignite inflammable mixtures. The question then arises, how is it possible to obviate the danger which may arise from this cause?

* *Transactions* of the Midland Institute of Mining Engineers, Vol. XI., p. 317, "Electricity as a Motive Power," with special reference to its application to mine-locomotives, December, 1889.

The authors, have devoted considerable attention to this matter. It should be taken as an axiom that the machine will not normally be placed to work in an explosive mixture; but that what has to be guarded against is, in the case of a motor which perhaps is not attended to for some hours at a stretch, the accumulation of such gases in its neighbourhood during this time. Moreover, where a motor is in use at the coal-face or in a heading, means should be adopted to allow the machine to be stopped if, in the working of the coal, or from the fall of a roof or other reason, an inrush of fire-damp should take place, before this explosive gas has had time to come in contact with the commutator and brushes.

To effect this purpose, the authors have adopted the practice of enclosing, either the whole armature together with the commutator and brushes, or when this is inconvenient, the commutator and brushes only, in a casing which is air-tight, or practically so. It has been objected to this plan, that although it may be feasible in the case of small motors, it is impracticable with machines of any size, owing to the diminished ventilation of the armature and commutator. The authors have, however, adopted the method with success for a motor which has developed up to between 40 and 45 H.P., and with no greater difficulty than in the case of one as small as 1 H.P. In the winding of field-magnets, it is now recognised that any desired temperature of working may be obtained by allowing well-defined amounts of external cooling surface for the dissipation of the heat developed. This proportion, for a final temperature of 70°F. above the atmosphere, may be taken as 2·3 square inches per watt to be dissipated.

The armatures of ordinary dynamos and motors are constructed to revolve in contact with the air, and the continual cooling thus obtained allows the surface for each watt to be dissipated for the same rise of temperature, to be diminished to about 0·7 square inch. In the case of the authors' mining motors, it is only necessary to revert to the basis adopted for the field-magnets, that is to say, to allow a cooling surface on the exterior of the armature-casing of the proportions which would be adopted for a stationary magnet-coil, in order to obtain the same result as to temperature. The armature revolving inside quickly brings the contained air to the same temperature, and this, being in rapid movement, conveys the heat to the external casing, from the surface of which it is dissipated by radiation and convection. It is true that to obtain a proper proportion between the cooling surface and the heat generated, it has been necessary to be careful as to the magnetic and electrical design of the armature; but with these precautions, the authors have found that the temperature of the armature of these enclosed motors at the end of a long run does not exceed that of the field-magnets.

Having thus disposed of the objection which has been raised by electrical engineers to this method, it remains to consider the question from the point of view of the mining engineer. The argument of the mining engineer is that if these casings should become filled with an explosive mixture and ignited, the result would be as disastrous as if they did not exist. The answer to this objection is as follows:—Seeing that under certain sections of the Coal Mines Regulation Act it is not allowable to work where the proportion of explosive gas exceeds about 1 in 30, it is not likely that any electric motor will be placed in such a position as to be run continuously in an explosive atmosphere for a longer period, at the outside, than two or three hours. The casings with which they are provided are tightly fitted at all the joints, many of them being packed with rubber, and it is not likely that an inflammable mixture could penetrate to a dangerous degree within that time. Should there, however, be any leakage into the covers, as soon as the proportion of marsh-gas in the air reaches 3 or 4 per cent., combustion will take place quietly, producing carbonic acid gas, which will tend to prevent explosion.

If, however, it is required to work for long periods in such an atmosphere, the authors would provide means for the introduction into the armature of an inexplosive mixture. The simplest

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method of producing this result would be to attach to the motor a steel cylinder containing carbon dioxide under pressure, and to connect this with the armature casing by a pipe which should allow a slow but constant stream of this gas to reach the interior of the casing. The efficacy of this method may be judged when it is pointed out that the presence of 14 per cent. of carbonic acid gas in the most explosive mixtures of fire-damp renders them absolutely uninflammable. The authors consider that this method of protecting the armature and commutator, and preventing the ingress of an explosive mixture, is generally more satisfactory than that of enclosing the commutator and brushes only as mentioned before. Conditions may, however, arise which render this latter method desirable. In that case the point to be aimed at is to produce a cover which shall give a similar protection to that afforded by a safety-lamp, and allow the ingress of the explosive atmosphere, but prevent the egress of flame. In order to do this it is necessary that the volume of the enclosed gases should be small, and that the passages through which the flame can escape should be of sufficient length, and the metal surfaces close enough together to cool it below the point of combustion. If the commutator were enclosed by a cylindrical case or otherwise, so that the volume of gas was small to begin with, yet as it wore away the space would increase to an undesirable extent. The authors have, therefore, designed methods by which it can be contracted and the volume of gas kept constant. But the brushes are not the only part which should be protected; for if a wire on the armature should break, or the insulation give way, or if anything should get between the armature and the pole-pieces, sparking might occur, and such a contingency should be provided for.

induction of the line and armatures. In order further to diminish this, the switch itself has, on its lower side, a resistance coil connected to the several points with which it makes contact, the wire being large enough to carry the current for the short time during which the switch is passing over them. By this means, even when the generator is short-circuited, the current is so far diminished that if the switch be moved slowly over the contacts, it is less than what has been termed the critical magnetising current of the dynamo. The result is that by the time the circuit is open the series-wound dynamo has practically ceased to excite itself, the electromotive force and current are very small, and the sparking practically *nil*.

As an additional safeguard, the switch itself is constructed in the form of an airtight box, which, in the same manner as the commutator covering, will exclude an explosive mixture for many hours. Although the authors have never tried the experiment, they have reason to believe that the amount of gas which could be possibly contained in the switch is not sufficient, should it ignite, to blow the cover off; while the surface of contact between the cover of the base and the cylindrical hole through which the handle passes, are sufficiently long to cool the escaping gas below the temperature of ignition. These precautions, which have been carried out successfully in practice, are, in their opinion, amply sufficient to meet all objections on the point of safety in connection with the application of electric motors to mining work.

Having so far dealt with the general question of the applicability of electrical power for mining machinery, and having indicated the methods adopted by the authors in their designs, it is proposed now to illustrate the application of these principles by some actual

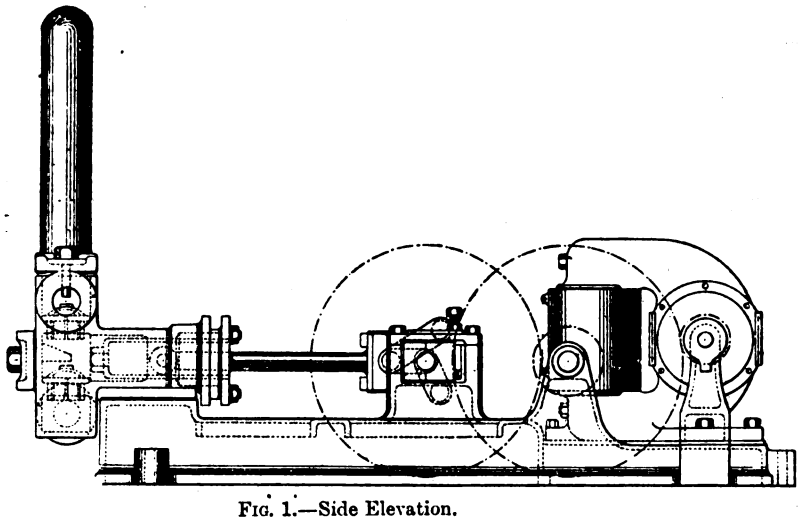

Fig. 1.—Side Elevation.

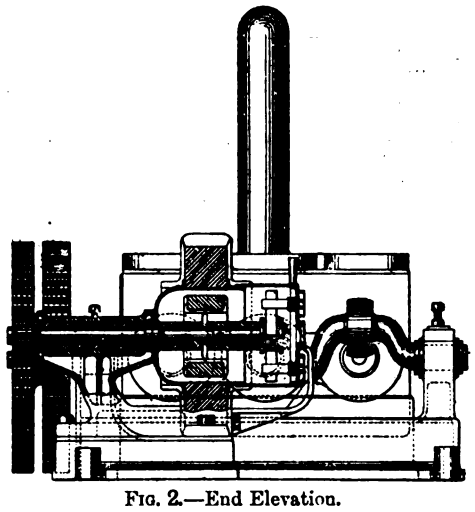

Fig. 2.—End Elevation.

Goolden Electric Dip Draining-Pump, with Enclosed Mining Motor.

There now remains the question of the switches connected with the motor, which will, of course, develope a spark on opening the circuit, when the current is flowing. This, in the opinion of the authors, is a more serious difficulty than the former one, and they have endeavoured to meet it in two ways, namely, by diminishing, as far as possible, the tendency to sparking, and by arranging a switch which, even in the event of a spark, would be safe under any conditions likely to occur. The first idea that occurs is that by using a shunt-wound dynamo as a generator and a shunt-wound motor, the self-induction in the circuit is so far diminished that little sparking is likely to occur. But for many purposes, the conveniences arising from using a series-wound motor, as will presently be pointed out, are such that this method is in general to be abandoned, although the principle underlying it may be adopted. The reason of the diminished sparking with the shunt-wound dynamos and motors is, that the self-induction of the cable circuit is insignificant, and that of the armatures is also small, whilst the circuits of the magnetising coils in both dynamo and motor, which have large co-efficients of self-induction, are always closed through the armature. Thus, although on breaking the circuit the current in the magnet-coils tends to continue, it has a path of discharge through the armature of low resistance and of small self-induction. The authors have, therefore, adopted the following plan:—In the case of a series-wound dynamo they have provided a resistance coil of small self-induction, which is always connected to the ends of the magnetising coil, so as to form a path through which a current in the latter may continue, even when the main circuit is broken. In the same way, they have arranged the switch in such a manner that before breaking the circuit the coil of the magnets is short-circuited. By this means, the act of breaking the circuit reproduces the conditions which exist in the case of a shunt-wound generator and shunt-wound motor, and the only sparking which results is that due to the self-

examples. Full descriptions have been already given of the application of electric power to mining work under conditions analogous to those existing in ordinary power transmission installations above ground; for instance, Mr. A. Snell, Assoc. M. Inst. C.E., has elaborately described a large pumping plant working at Normanton,* and, in a Paper previously mentioned, by Mr. G. Blake Walker,† the application to locomotive work of accumulators has been fully discussed. The authors, therefore, propose to confine their attention to two or three illustrations of the use of electrical power, both in fixed plant and in machinery which is constantly moving from place to place whilst at work. For this purpose they have selected some dip-draining pumps, which are portable but are fixed whilst working; and they propose also to describe electrical coal-cutting machinery, electric coal-borers and electric rock-drills, as examples of constantly moving plant.

The earliest example of the application of electricity in mining work was its adoption by Mr. W. B. Brain, for draining a certain part of the Trafalgar colliery in the Forest of Dean.‡ An ordinary horizontal pump was driven by a belt from the motor, which was fixed upon a permanent bedplate. The arrangement has worked well and given satisfaction; but, in the opinion of the authors, the use of belts in coal-mining work, unless under very exceptional conditions, is entirely out of the question, owing to want of space and the difficulty of keeping them in good working condition in dirty and wet situations.

In Figs. 1 and 2 is illustrated a horizontal drip-draining pump, designed by the authors, and constructed by Messrs. W. T. Goolden and Co. Three-throw ram-pumps are used, the reason being that it

* National Association of Colliery Managers, September 28, 1889.

† *Transactions* of the Midland Institute of Mining Engineers, Vol. XI., p. 317.

‡ *Proceedings* of the South Wales Institute of Engineers, Vol. XIII., p. 277.

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is important in using electric motors that the load should be as regular as possible throughout the revolution. The pumps are mounted upon a bed-plate, which is extended to carry the motor. The motion is communicated from the motor shaft to the pump shaft by gearing. This method of reducing the speed is perhaps more noisy than the use of belts, but in practical working this is not of much importance; and, provided that the armature is properly constructed for the purpose, ample strength being given, and proper materials being used to avoid the result of the jar or shock, gearing may be confidently recommended. It requires no adjustment, and is so compact that the whole machine is self-contained, whilst, when the pinion on the motor, which is subjected to the greatest wear, is worn out, it can be replaced in a few minutes at a trifling cost.

Table III.

Pattern of Pump.	H.P. on belt.	H.P. at terminals of dynamo.	Volts at dynamo.	Size of cable.	Distance in yards dynamo pump.	H.P. lost in cables.	Per cent. of total H.P.	H.P. lost in motor.	Per cent. of total H.P.
Vertical	3·3	2·95	100	7/15	560	0·56	17·0	0·35	10·6
Horizontal ...	2·9	2·57	175	7/18	2,000	0·98	33·8	0·23	7·9

Pattern of Pump.	H.P. lost in pump and gearing.	Per cent. of total H.P.	H.P. lost in pipes.	Per cent. of total H.P.	H.P. in water delivered.	Per cent. of total H.P.	Height water is forced.	Gallons per minute.	Gross efficiency transmission.	Size of rams.
										Ins.
Vertical...	0·6	18·2	0·165	5·0	1·260	38·4	170	24·3	43·4	3
Horizontal	0·47	16·2	0·600	20·7	0·288	10·0	19	50·0	30·7	3¾

Table III. gives the data of a pump of the horizontal pattern, and vertical pattern, and shows the relative efficiency of the various parts together with the size of rams. The gross efficiency is not very high, owing largely to the power used being small. But it was specially intended to produce a durable machine, suited for the rough conditions under which it was likely to be worked, and adapted also to be handled by persons who have not the necessary knowledge to keep any delicate mechanism in adjustment. These considerations necessitated the adoption of a large clearance for the armature, ample space for insulation, &c., all of which tended to diminish the efficiency. The motors, it will be observed, are of the authors' enclosed type, the field-magnet coils being lagged with steel to prevent mechanical damage. These machines have, in some cases, run for many weeks, day and night together, with no attention beyond an occasional feeding up of the brushes and lubrication. This form of pump is well adapted for mines where the electric light is already installed, and in this connection attention may be drawn to a point which is worthy of note. In the use of electricity for motive power for lighting it has often been objected that the variations in the load upon the motor cause a considerable alteration in the lights upon the same main at some distance from the dynamo. The remedy for this is simple. By employing a well-governed engine, and compound wound dynamo, the electrical pressure at the terminals of the generator may be kept constant; if, then, a separate pair of mains is run for the motors, the pressure on the wires feeding the lamps is constant, whilst any variation at the terminals of the motor is not a matter of importance. These electrical pumps appear to meet every requirement of practical mining work, and have replaced steam and hydraulic pumps with considerable advantage.

(To be continued.)

THE PICARD SYSTEM OF SIMULTANEOUS TELEGRAPHY AND TELEPHONY.

In view of the recent satisfactory tests which have been made by the French Postal Telegraph officials, the following description of a new system of simultaneous telegraphy and telephony will prove interesting. The idea is due to M. Pierre Picard, belonging to the French Telegraphs, and the following particulars are from an article by M. A. Michaut in *L'Electricien*.

M. Picard employs a device which he calls a "differential transformer," which is nothing more than a cylindrical induction coil with four wires of equal resistance and the same dimensions wound together on a soft iron core. The coil is mounted on a wooden base provided with four terminals, by means of which the four coils are connected to the line and to the local circuit as shown diagrammatically in the following figures.

In Figure 1 we have a diagram of the simplest arrangement. The opposite ends of the coils *a b* are joined together. To each of their other extremities one of the line wires is attached. The two line wires are thus looped together for telephony, and are at the

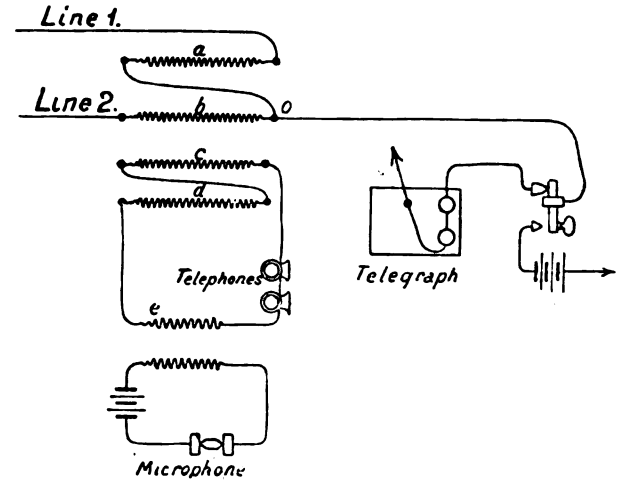

Fig. 1.

same time connected in parallel for telegraphy. The ends of the other two coils *c* and *d* of the "transformer" are similarly connected, a local telephone circuit taking the place of the line.

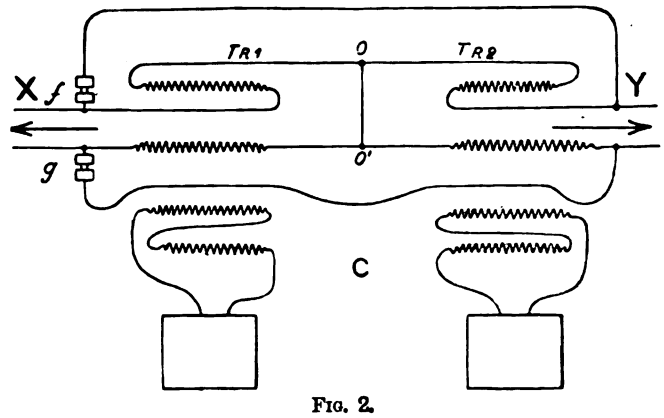

Fig. 2.

If we look at the diagrams we can easily see (1), that the *telegraphic* currents divide equally between the two coils *a* and *b*, and while they go along the two line conductors in the same direction traverse the coils *a* and *b* in opposite senses; (2), that the *main telephonic* currents, which take opposite directions along the line, traverse the transformer coils in the same sense; (3), that the *local telephonic* currents traverse the coils *c* and *d* in the same direction. The result of all this is that telegraphic currents, whether they bifurcate

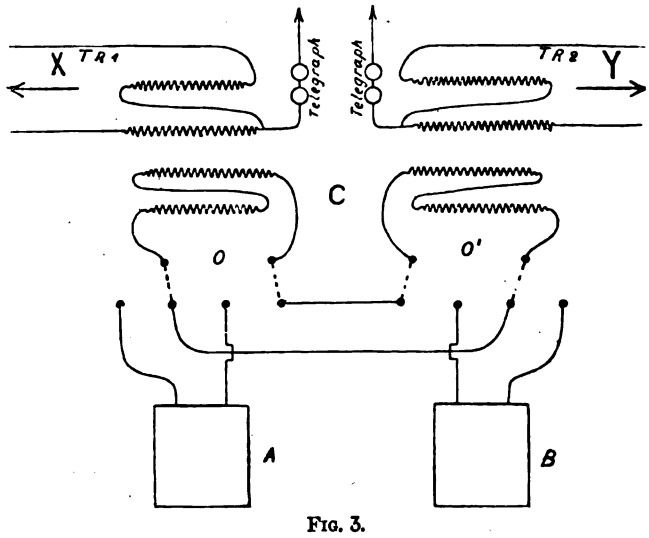

Fig. 3.

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at O on going to line or unite at this point on going to the receiving instrument, have an equal and opposite inductive influence when traversing the coils *a* and *b*, and the telephone consequently remains silent. When the microphone is spoken to, the induction currents developed in *e* traverse the coils *c* and *d* in the same direction, and induce currents in the coils *a* and *b* which actuate the telephone at the far end of the line.

If it is required to cut the telegraph line in half without interrupting through telegraphy, the *modus operandi* shown diagrammatically in Fig. 2 is followed. At the intermediate station C are the two transformers, A and B. The first transformer, Tr_1, is connected, as described above, to the two wires going to station X, the transformer Tr_2 being similarly connected to station Y. From the intermediate post C it is, therefore, possible to telephone to X and Y, or these two stations may be placed in through communication by operating the connections O O′ at station C.

The converse problem can also be solved—that is to say, the telegraph circuit can go through, and the telephone circuit can be divided. This is shown diagrammatically in Fig. 3. As before, two "transformers" are employed at C, but the wires, instead of being looped on either side of C, run through without being broken; they are, however, connected together between the two "transformers" by a conductor, O O′, of negligible resistance, called by M. Picard a "telephonic bridge." The presence of the conductors O O′ does not in any way disturb the condition of the telegraph line, since the two wires are in parallel for telegraphic purposes. It is not, however, the same for the two looped telephone wires on the right and left of station C. In this case O O′ acts as a short circuit, and prevents the through passage of the telephone currents, so that conversation may be carried on simultaneously with C from X and Y. If it is required to speak through from X to Y, the transformers, &c., are cut out of circuit by inserting plugs at the points *f* and *g*.

In the tests made between Paris, Lyons, and Marseilles the interposition of the "transformers" permitted the simultaneous exchange of telegraphic and telephonic communication. But when the Picard apparatus was fixed to the Paris-Troyes line a very different result was obtained. One wire was old, the other recently erected; their electrostatic capacity was by no means the same, and audition was impossible. On equalising the capacities all went well. The Picard system, it is stated, will allow the Baudot apparatus to be used, which is not the case with that of Van Ryssel-berghe.

A METHOD OF DETERMINING INSTANTANEOUS VALUES OF A PERIODIC E.M.F.*

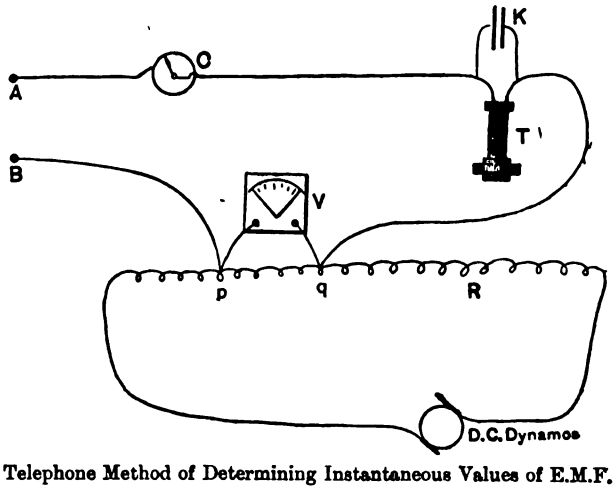
BY RALPH D. MERSHON.

The methods heretofore in use for measuring instantaneous values of E.M.F. in the determination of the wave form of a periodic E.M.F. are those employing the ballistic galvanometer and electrometer. Some time ago another method suggested itself to me, which, by the kindness of the Westinghouse Electric and Manufacturing Company, through Mr. Chas. F. Scott, the assistant electrician, I have been enabled to thoroughly test, and have found both convenient and accurate.

The needle of a galvanometer in series with a contact device and the periodic E.M.F. will, if its time of vibration is sufficiently great, be steadily deflected by the succession of impulses it receives. If there be placed in series with the contact device, galvanometer and periodic E.M.F., a steady E.M.F., which at the instant of contact opposes the first, and it be varied until the galvanometer deflection is zero, its value will be that of the periodic E.M.F. at the point on its wave for which the contact device is set. This mode of procedure is unsatisfactory, however, for small voltages, as in that case the deflections on an ordinary low-resistance mirror galvanometer in fairly delicate adjustment are small, even though there be a condenser of several microfarads in parallel with it. A plan much better both as to accuracy and convenience is that of replacing the galvanometer with a telephone receiver.

In the diagram let A B represent the terminals of the source of a periodic E.M.F. whose wave form is to be determined. C is the contact device attached, of course, to the shaft of the generator furnishing the periodic E.M.F. T is a telephone receiver which may have in parallel with it a condenser K. R is a resistance in series with a direct current dynamo or storage battery; a part of R consists of a slide wire resistance along which the sliding contact *p* can be moved. V is a direct-current voltmeter. Suppose the sliding contact *p* to be moved to *q*. The contact device C being set for some point on the E.M.F. wave other than zero, there will be heard in the telephone a succession of sharp clicks—one for every revolution of the contact device. If *p* be moved away from *q* and the fall of potential between the points *p* and *q* on the resistance R be in such a direction as to oppose that between A and B at the point on the wave for which the contact device is set, the loudness of the clicks heard in the telephone will diminish with such movement, and a place may be found at which they are no longer heard, and beyond which they become again audible. This place corresponds to an approximate equality of the steady and the unknown E.M.F., and the reading on the voltmeter gives to a certain degree of accuracy the required instantaneous value of the periodic E.M.F. For a more accurate determination we must adjust to zero sound by moving *p* up first from one side of the zero point, then from the other. In general the two settings obtained in this way will not coincide, since there is a limit to the current which can be detected by the telephone, and the point midway between them on the slide-wire resistance must be taken as the true setting. The voltmeter reading gives them the true value.

The delicacy of the telephone is much increased by placing in parallel with it a condenser. Great delicacy is not at all times, however, desirable. Should the belt driving the generator of the periodic E.M.F. have bad joints in it, or vibrate much, the variation in speed due to either or both of these causes can be plainly noted in the telephone, as some of the clicks will be louder than others. With a delicate telephone it will probably be the case under these conditions that no point can be found at which there is no sound; whereas, if the instrument be less delicate, we may find two points of zero sound and interpolate as explained above.



Telephone Method of Determining Instantaneous Values of E.M.F.

Hence, in some cases it is desirable to diminish the delicacy of the telephone by putting resistance in series with it. There is, practically, no limit to the accuracy with which settings can be made with the proper form of apparatus. Using an ordinary Bell telephone receiver, it is easily possible to make settings to $\frac{1}{100}$ of a volt.

The apparatus for the method is simple. It can be put in compact form, and thus be always available at an instant's notice, as it requires neither adjustment nor calibration.

* From *The Electrical World*.

THE ANNEALING OF COPPER.*

BY MR. C. W. CUMMINGS.

Copper is at present almost universally annealed in muffles, in which it is raised to the desired temperature, and subsequently allowed to cool either in the air or in water. It is necessary to watch the copper carefully, so that when it has reached the right temperature it may be drawn from the muffle and allowed to cool. If the copper is heated to too high a temperature, or is left in the muffle at the ordinary temperature of annealing for too long a time, it is "burnt," as the workmen say. Copper that has been "burnt" is yellow, coarsely granular, and exceedingly brittle—so much so, that in some samples it cannot be bent once at a right angle without breaking. It is even more brittle at a red heat than when cold. In the case of coarse wire it is found that only the surface is "burnt," while the interior is damaged to a far less extent. This causes the exterior to split loose from the interior when bent or rolled, thus giving the appearance of a brittle copper tube with a copper wire snugly fitted into it. Cracks a half-inch in depth have been observed on the surface of an ingot on its first pass through the rolls, all due to the exterior "burning." It is quite apparent that copper that has been overheated in the muffle is entirely unfit for rolling, either for rods, or sheet-copper, or for wire-drawing. It is found that the purer forms of copper are far less liable to be harmed by over-

* From the *Journal of Commerce and Inter-Colonial Trader*.

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heating than samples containing even a small amount of impurities. Even the ordinary heating in a muffle will suffice to "burn" in this manner the surface of some specimens of copper, and thus render them entirely unfit for further working. Copper that has been thus ruined is of use only to be refined again. As may be inferred from the above, only the highest grades of refined copper are at present used for drawing or rolling. This is not because the lower grades, when refined, cannot stand sufficiently high tests, but because the present methods of working are not adequate to prevent these grades of copper from experiencing the deterioration due to overheating. This is unfortunate for the manufacturer, since, I understand, he has to pay cash in advance for the highest grades of refined copper.

In order better to appreciate the explanation of the various phenomena of copper annealing, let us see what refined copper is.

The process of refining copper consists in an oxidising action followed by a reducing action which, since it is performed by the aid of gases generated by stirring the melted copper with a pole, is called poling. The object of the oxidation is to oxidise, and either volatilise or turn to slag all the impurities contained in the copper. This procedure is materially aided by the fact that the suboxide of copper is freely soluble in metallic copper, and thus penetrates to all parts of the copper, and, parting with its oxygen, oxidises the impurities. The object of the reducing part of the refining process is to change the excess of the suboxide of copper to metallic copper. Copper containing even less than 1 per cent. of the suboxide of copper shows decreased malleability and ductility, and is both cold short and red short. If the copper to be refined contains any impurities, such as arsenic or antimony, it is well not to remove too much of the oxygen in the refining process. If this is done, "over-poled" copper is produced. In this condition it is brittle, granular, of a shiny yellow colour, and more red short than cold short. When the refining has been properly done, and neither too much nor too little oxygen is present, the copper is in the condition of "tough pitch," and is in a fit state to be worked. "Copper is said to be tough pitch when it requires frequent bendings to break it, and when, after it is broken, the colour is pale red, the fracture has a silky lustre, and is fibrous like a tuft of silk." On hammering a piece to a thin plate, it should show no cracks at the edge. At tough pitch copper offers the highest degree of malleability and ductility of which a given specimen is capable. This is the condition in which refined copper occurs in the market, and if it could be worked without changing this tough pitch, any specimen of copper that could be brought to this condition would be suitable for rolling or drawing.

We have seen that tough pitch is changed if we either add oxygen to, or take oxygen from, refined copper. By far the more important of these is the removal of oxygen, especially from those specimens that contain more than a trace of impurities. That is shown by the absolutely worthless condition of overpoled copper. The addition of carbon also plays a very important part in the production of overpoled copper. That the addition of oxygen to refined copper is not so damaging is shown by the fact that at present nearly all the copper that is worked is considerably oxidised at some stage of the process, and not especially to its detriment.

Let us see how the above facts are related to the process of annealing copper. I have already referred to what is known as "burnt" copper. This is nothing more nor less than copper in the overpoled condition. This is brought about by the action of reducing gases in the muffle. By this means the small amount of oxygen necessary to give the copper its tough pitch is removed. This oxygen is combined with impurities in the copper, and thus renders them inert. For example, as explained by Dr. Peters, the oxide of arsenic or antimony is incapable of combining more than mechanically with the copper, but when its oxygen is removed, the arsenic or antimony is left free to combine with the copper. This forms a very brittle alloy, and one that corresponds almost exactly in its properties to overpoled copper. To be sure, overpoled copper is supposed to contain carbon, but that this is not the essentially ruining principle in case of annealing is shown by the fact that pure copper does not undergo this change under conditions that ruin impure copper, and also by the fact that the same state may be produced by annealing in pure hydrogen and thus removing the oxygen that renders the arsenic or antimony inert. No attempt has been made to deny the well-known fact that carbon does combine with copper to the extent 0·2 per cent., and cause it to become exceedingly brittle. It is simply claimed that this is probably not what occurs in the production of so-called burnt copper during annealing. The amount of impurities capable of rendering copper easily "burnt" is exceedingly small. This may be better appreciated when it is considered that from 0·01 to 0·2 per cent. expresses the amount of oxygen necessary to render the impurities inert. The removal of this very small amount of oxygen, which is often so small as to be almost within the limits of the errors of analysis, will suffice to render copper overpoled and ruin it for any use.

It is quite apparent that a really good method of annealing copper will prevent any change in the state of oxidation. To accomplish this it is necessary to prevent access to the heated copper both of atmospheric air, which would oxidise it, and of the reducing gases used in heating the muffle, which would take oxygen away from it. Obviously the only way of accomplishing this is to enclose the copper when heated, and till cool, in an atmosphere that can neither oxidise nor deoxidise copper. I find that by so doing copper may be heated to the melting point and allowed to cool again without suffering at all as regards its pitch. There are comparatively few gases that can be used for this purpose, but, fortunately, one which is exceedingly cheap and universally prevalent, fulfils all requirements—viz., steam.

In order to apply, then, in practice the principles already enunciated, it is necessary only to anneal copper in the ordinary annealing pots, such as are used for iron, care being taken to enclose the copper while heating and while cooling in an atmosphere of steam. This will effectually exclude air and prevent the ingress of gases used in heating the annealer. Twenty-four hours may be used in the process, as in the annealing of iron wire, with no detriment to the wire. This may seem incredible to those manufacturers who have tried to anneal copper wire after the manner of annealing iron wire. By this method perfectly bright annealed wire may be produced. Such a process of annealing copper offers many advantages. It allows one to use a grade of copper that has hitherto been worked only at a great disadvantage, owing to the ease with which it gets out of pitch. It allows one to use annealers such as are ordinarily used for annealing iron, and thus cheapens the annealing considerably as compared with the present universal use of muffles. There is no chance of producing the overpoled condition from the action of reducing gases used in heating the muffles. There is no chance of producing underpoled condition due to the absorption of suboxide of copper. None of the metal is lost as scale, and the saving that is thus effected amounts to a considerable percentage of the total value of the copper. The expense and time of cleaning are wholly saved. Incidentally bright annealed copper is produced by a process which is applicable to copper of any shape, size, or condition, a product that has hitherto been obtained only by processes (mostly secret) which are too cumbersome and too expensive for extensive use, and, as in the case with at least one process with which the author is acquainted, with the danger of producing the overpoled condition, often in only a small section of the wire, but thus ruining the whole piece. If it is desired, the copper may be annealed in an apparatus so arranged that the copper when heated may be dropped into a body of water without access of air, and thus make a far smaller annealing plant suffice. It may be mentioned that copper seems to be made neither softer nor harder by being cooled suddenly in this manner than if cooled slowly, though some of the alloys of copper are rendered somewhat softer by a sudden cooling; in fact, there is not the slightest evidence anywhere to justify the quite prevalent belief that an art of hardening copper was known to the ancients. The hardest tools of the ancients were made of bronze, not copper. By application of the same principles it is possible to prevent both deoxidation and oxidation in the heating of copper ingots for the rolls, and thus, by keeping copper at tough pitch all along, any copper that can be given tough pitch can be used for rolling sheet copper or for wire. I think it also practicable to produce bright copper rods direct from rolls.

ELECTRICITY IN THE PRODUCTION OF ALUMINIUM.*

BY ALEXANDER S. BROWN.

The glamour that has surrounded this metal since 1856, when H. St. Claire Deville first obtained it in sufficient quantities to study its physical and chemical characteristics, and the almost monthly presentation before one or other of our scientific societies of Papers treating of its properties, &c., make it a most difficult subject to handle with originality. Scientific and newspaper eulogists have expended a great deal of time and many words in extolling the unusual combination of useful properties which it possesses, and have given their imaginations full play in describing its future triumphs in the metallurgical world; but as yet little has been actually accomplished in the way of accurately determining the commercial status and mechanical value of this metal compared to others more familiar to us. While it must be confessed that in certain respects its merits seem such as to warrant great expectations, those interested in its production and its commercial success have experienced not only the usual difficulties inseparable from the introduction of any new metal, but many others due to the too great esteem which the public has been led to bestow upon it. When sufficient knowledge of its characteristics has been acquired there is little doubt it will make for itself new and important fields of usefulness.

Patronised by Napoleon the Third, who entertained great expectations concerning the use of the metal in war equipment,

* A Paper read before the American Institute of Electrical Engineers.

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Deville established commercial works near Paris, which, after varying fortunes, were finally permanently located at Salindres, France, and these works for many years produced substantially all the pure aluminium consumed in the world. It may interest you to know that up to 1886 the annual production of this metal was less than 10,000 pounds, of which 6,000 to 8,000 pounds were produced in France. In 1860 it sold at over $90 per pound. In 1887 it was sold at $5 per pound, and is now selling at $1 for a commercially pure article—this term signifying about 97 per cent. purity in the metal. Spasmodic attempts to establish aluminium works were made in Germany and other countries; but it may be truthfully said that France, which created that industry, remained its home until the development of the electrical processes which have now superseded all others.

During the development of the various sodium processes the possibility of utilising electricity was not neglected. Among the earliest patentees in this field were Camille A. Faure, in 1880-84, and R. Grätzel, in 1883.

On April 2, 1889, Mr. Charles M. Hall, of Oberlin, Ohio, secured patents for a process of reducing pure aluminium. In this process alumina is dissolved in a fluid bath composed of aluminium fluoride and potassium fluoride, with, perhaps, an addition of lithium fluoride; this bath then being electrolysed by means of an electric current conveyed to a carbon-lined furnace through an anode of some non-carbonaceous material. In electrolysing this bath, the containing vessel is made to serve the purpose of the negative electrode. In another patent Mr. Hall claims the use of a bath composed of alumina dissolved in compound fluorides of aluminium with alkaline earthy metals, and in still another patent the use of a bath composed of alumina dissolved in the fluorides of aluminium, calcium, and sodium, these materials being obtained by melting together aluminium fluoride, fluorspar, and kyrolite. With this latter bath a carbon anode can be used without the bath being affected by its disintegration. The Hall group of patents is now controlled by the Pittsburgh Reduction Company, of Pittsburgh, Pa., which has had its metal on the market since March, 1889. The plant has a daily capacity for producing about 300lb. of metal, the selling price of which was $2 per pound until the early part of March last, when it was reduced to $1 per pound for commercially pure aluminium of a guaranteed purity of 97 per cent.

The reduction in price, considered in conjunction with the limited amount of pure metal produced, would appear to confirm the generally received impression that while the pure metal is specially adapted to the manufacture of articles of art and ornament, it is not displacing tin, platinum, silver, &c., to anything like the extent its admirers have supposed it would. The fact is, aluminium as a pure metal is not destined largely to supplant other metals in the arts and manufactures; it is to its alloys that we must look to redeem the inflated reputation of the pure metal. The true value and use of aluminium seems to have been forecast by Deville, who predicted for it an intermediate position between the precious and baser metals, in which relation to manufactures he said it was destined to fill a long-felt and important want. He doubtless referred to the pure metal, but, curiously enough, his prediction applies with greater force to its alloys, which have been demonstrated by actual use and thorough tests to possess physical and chemical properties that place them above all other alloys of copper, iron, and in some instances even of steel.

The electric smelting process of the Messrs. Cowles, of Cleveland, Ohio, was the first to secure a commercial footing in this country. The process may be described as the reduction of metals by smelting their ores with heat produced by the passage of an electric current through broken resistance material—that is, in the presence of an incandescent material (carbon being generally preferred). Stress is laid on the alleged fact that the reduction is purely and solely a smelting operation, due to a heat far greater than can be obtained by any agency other than the electric current. The electrical (chemical) effect of the current is distinctly disclaimed. The furnaces used are rectangular, and oblong in shape, comparatively shallow, and are composed exteriorly of walls of firebrick or metal, lined with pulverised charcoal or other form of carbon or similar material of electrical conductivity inferior to the ore to be smelted, this material being generally previously saturated with lime water to increase its resistance to heat. At each end of these furnaces are inserted rods of carbon, which, passing through the walls and linings, are brought very nearly into contact within the body of the furnace, and being connected to suitable wires or cables coupled to the dynamo, constitute the positive and negative electrodes. The charge consists ordinarily of a mixture (in different proportions) of an electrically resisting material—such as electric light carbon—and the ore to be reduced; though (in cases where the ore itself has sufficient electric resistance) the carbon is sometimes dispensed with. When a current of electricity is passed, the electrodes are so adjusted as to form an arc, and the current then flows from the sides and ends of the electrodes through the broken resistance material, which, of course becomes incandescent, and the intense heat developed by this incandescence reduces the ore, the metal flowing to the bottom of the crucible and being subsequently tapped or dipped out when the charge is consumed. Neither aluminium nor any other metal is produced on a commercial scale by this process *as pure metal*.

The principal rival to the Cowles process for producing aluminium alloys is the Heroult process, which reduces aluminium and other metals from their refractory ores in the presence of another alloying metal, and is contradistinguished from the Cowles process mainly by the fact that it operates exclusively—or at least almost entirely—by utilising the chemical or electrolysing action of the current.

Though the Heroult processes have been very little discussed or even described in print, and are therefore almost wholly unknown to the public, their commercial success abroad has been far greater than has attended any other aluminium process; and while those owning the American patents seem as yet to have done little in the way of exploiting them, the success of a small plant put into operation at Boonton, N.J., for private demonstration purposes, in April, 1890, has been such as to give it rank among the prominent aluminium processes in this country. The crucible in the Heroult process is composed of a strong iron box, which has a deep lining of carbon, previously ground very fine, mixed with sufficient tar and thoroughly compacted on the bottom and around the sides of the containing iron box. After the furnace is thus relined, the carbon is baked in order to drive away the tar and harden the lining. You will see that the position of this crucible is directly the reverse of those used by the Cowles Company, and that the carbon crucible itself actually forms part of the electric circuit. Unlike the Cowles process, Heroult's is a continuous process, the reduced metal being tapped from the bottom of the crucible, while the machine is merely stopped or slowed down for a few minutes. The interior dimensions of the crucible vary with the ore to be reduced and the size and character of the anode used. Ordinarily it has an interior depth of about 22in. and a clear space of 6in. between the walls and exterior surface of the anode. The electric current passes into the crucible through the suspended carbon anode, the vertical position of which is controlled by an attendant, who lowers it from time to time, to preserve an approximately constant distance between the bottom of the anode and the surface of the molten bath in the crucible. The anode usually dips several inches into this molten bath, and, in practice, the intervening space between its bottom and the surface of the molten metal is kept at about an inch by the attendant, who, by watching the needle in the ammeter, is enabled to maintain the electrode in its proper relative position without difficulty. In order to get as perfect a contact as possible, between the furnace and the cables leading therefrom back to the dynamo, the cables are firmly clamped to a large block of zinc, which projects from the rear of the furnace, and is kept cool by water circulating in pipes, around which the zinc is cast.

There are a few distinctive, but not important differences, between Heroult's method of making alloys and reducing pure metals simply. In making alloys, the base alloying metal is first melted in the crucible by the current, or molten metal is poured into the furnace, to form a liquid metallic cathode. This is usually simply and economically accomplished by throwing pieces of the metal—copper, for instance—into the furnace, seating the anode upon them, and passing the current. At first the current is very unsteady, and constantly forming between the copper and the anode, but when the copper is entirely melted (and it takes but a very few minutes to melt 200 or 300lb.) the ore to be reduced is added in sufficient quantities to form a bath, and floats on top of the molten copper. The anode having been raised so as to leave a space of about an inch between its bottom and the molten copper, the current becomes steady, and the operation is established. Thereafter the ore is introduced in small quantities, at frequent and regular intervals, until the desired percentages of aluminium or silicon contained in the alloy have been secured. This percentage can be regulated entirely at will up to about 70 per cent. of reduced metal. No external heat is used, and the process is absolutely continuous at the will of the operatives, which are special features of the Heroult system. The passage of the electric current through the bath serves not only to keep the copper in a fluid state and to melt the ore, but also electrolyses and decomposes the latter. It is a point of careful regulation in the Heroult processes to maintain only sufficient heat to keep the bath fluid, since any further expenditure is not only useless, but lessens the output. The oxygen from the reduced metal combining with the carbon, of which the anode is composed, is burned with the production of carbonic oxide gas, which escapes from the crucible around the sides of the anode and at the feed hole. The product is withdrawn at intervals by tapping the bottom of the crucible as in ordinary smelting. Each time the metal is tapped, a sample is carefully preserved for accurate analysis, to determine the percentage of contained aluminium.

From a metallurgical point of view, the amount of labour required to operate this process is astonishingly small. The metal

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produced in the Heroult furnace is sold generally in ingot form, just as it is tapped, without re-melting or being subjected to any purifying manipulation. It is always, however, very pure, sometimes dropping as low as 98½, but generally running over 99 per cent. of absolute purity.

The compounds of aluminium formed by the addition of copper, brass or iron, are unquestionably the most commercially important of the aluminium alloys. Aluminium combines with copper in all proportions, but its alloys are as easily influenced by impurities as is the pure metal. It is an important fact worth noting that, when alloys are made by mechanically mixing aluminium and copper, iron, &c., the product must be re-melted a number of times to secure any uniformity in the texture of the alloy. The finest alloys, by far, are those made by uniting the aluminium to the basic metal in atomic proportions as it is reduced, as in the Heroult process, the uniformity of whose alloys is remarkable. Probably the most useful compound of aluminium and copper is what is known as 10 per cent. bronze, containing 10 per cent. aluminium, and 90 per cent. of copper. This alloy is an almost perfect imitation of gold in colour, and is susceptible of taking and retaining a most beautiful polish. It can be rolled, or drawn, or cast very readily, but in casting the bronze shrinks considerably, and care must be taken to have the feeders amply large. The tensile strength of this bronze is enormous.

THE TELEPHONE.

The following letter appeared in *The Times* of Monday :—

TO THE EDITOR OF THE TIMES.

SIR,—Since my name has been mentioned several times in the course of the correspondence, I would crave indulgence for a few remarks, especially as Mr. F. Faithfull Begg, in his last letter, puts the plain question, "Can London be telephoned efficiently and profitably for a £10 subscription ?" a query which I anticipated and answered in the affirmative in the Paper I recently contributed to the British Association at Cardiff. If Mr. Begg has access to the National Telephone Company's books, he will find therein plenty of material to convince him of the practicability of the proposition. Especially would I refer him to the accounts relating to Dundee, Aberdeen, Inverness, Galashiels, and Dumfries, in Scotland, between the years 1883-90, and to Whitehaven and Carlisle, in England, between the years 1885-9. It was in these towns that modern telephone construction was first introduced and practised, and where the results flowing from good work and intelligent, conscientious supervision were first demonstrated. He will find that these centres yield, or did until last year, a greater return on the capital invested than any of the richer English towns, where the bad management which for the two first years of its existence (1881-82) characterised the old National Telephone Company held sway long after it had ceased in the north. He will discover that a company undertaking the telephoning of moderately-sized towns on a £10 tariff, and having to earn interest only on the capital actually invested, will be able to pay a dividend closely approaching 20 per cent. per annum. Now, a new company undertaking the telephoning of London would have nothing to pay for patents, and, I trust, would not be burdened with any bogus capital. It would have the example of the Scottish practice before it, and the benefit also of the Mutual Telephone Company's more recent experience in Manchester. It would likewise possess the sympathies of the London public, so long alienated by the imbecilities of the existing company. Starting thus with a fair wind it would need no favour, and only persistent bad management could prevent its earning a 10 per cent. dividend on a £10 tariff. Mr. Begg may say that Aberdeen is not London, and that what is possible in the one place may be visionary in the other. But I have had experience in managing telephonic exchange business in London as well as in Scotland, and, although I am aware that conditions differ in some respects, I also know that the variations are not radical, and are capable of being allowed for. It was to equalise these differences that the plan set forth in my Cardiff Paper was designed. The average length of a London subscriber's line, according to my plan, would be only 440 yards, while the average length of a Scottish subscriber's is very much greater, so that the prime cost of each would not be markedly different, even allowing for the additional expense of the twin wire which would be used in London. The approximate cost, including labour and general expenses, of each subscriber's connection would be—

Office instrument and fittings	£3	0	0
Line (440 yards average)	5	10	0
Switch-board and other exchange fittings	1	10	0
Total	£10	0	0

This would join the subscriber to the sectional switch-room, but he would still have to bear a proportion of the cost of the junction wires linking the sectional-room to the central. After mature consideration I have estimated that £10 per subscriber would be a most liberal allowance for this purpose, and thus arrive at a total of £20 as the cost of each subscriber's installation. Deducting 50 per cent. of the £10 subscription for working expenses (including Post Office royalty), which prolonged experience teaches me is amply sufficient, a dividend of 25 per cent. would result. But I do not anticipate such an issue on a £10 tariff. Much of the work would have to be underground, and the special conditions existing in London must be provided for. To meet these contingencies I would add £30 to the cost of each subscriber's installation, making the total £50 per subscriber, which, with a net revenue of £5, would yield a dividend of 10 per cent. Mr. Begg may realise the weakness of his contention by asking an experienced, independent telephone engineer, who knows how to obtain material in the best markets, to jot down for him how it would be possible, with fair dealing, to expend £50 on a twin line 440 yards long and a proportion of a junction line. I have taken a £10 rate because Mr. Begg specially mentions it, but personally, as I state in my Cardiff Paper, I believe that a good dividend could be earned on £8. Mr. Begg must discard all of the old company's figures and statistics except those for the northern towns I have named, for such are entirely misleading and inapplicable. They would be useful as a basis of comparison if the new company proposed to erect silver wire plated with gold and to embellish their subscribers' instruments with emeralds, but not otherwise.

Mr. Begg, in his first letter, expressed great belief in the efficacy of the reconstruction of the London over-house work now proceeding. I am sorry that I cannot share this faith. With the nature of this reconstruction we are made acquainted by the report of the National Telephone Company's recent annual general meeting. It consists in the introduction into London of the system I designed for the old National Company's Scottish centres so far back as 1883, and which, established at first in the face of vehement opposition, was subsequently copied in all their other provincial districts. It is now, after the lapse of eight years, being copied in London also, at the cost of many thousands of pounds, and is relied upon to extricate the Company from all its troubles. But, Sir, flattering to me as this expectation unquestionably is, I must point out that this system of mine, consisting of channel-iron cross-arms, upright insulators, and light bronze wire forms but a mere detail of an efficient telephonic exchange. It is insufficient in itself to improve the service; it must be supplemented by as radical changes in every other department and such changes, according to the reports which reach my ear, are not being made. This view is confirmed by the complaint made at the general meeting by one of the shareholders—a Mr. Harris, I believe—that, although his line had been reconstructed, his service continued as inefficient as before. That is exactly what I should have predicted, and I anticipate that, after the whole over-house reconstruction has been effected, the service generally will be as bad as it is now. I consider the position of the Company the more serious because, from the statement made by their Chairman at the general meeting, it is evident that they do not understand the nature of the disease which is consuming their vitals. To expect the changes he indicates to save them is absurd. His position is comparable to that of an architect who might propose to counteract the effects of unstable foundations by changing the shape of the weather vane on his building from a cock to a butterfly.—I am, Sir, yours, &c.,

A. R. BENNETT.

Britannia Hof, Frankfort-on-Main, September 9th.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *September* 5, 1891.

The Edison General Electric Company.—A report is current about town that Mr. Henry Villard, president of the Edison General Electric Company, has sent in a peremptory letter of resignation. It is understood that a considerable amount of the capital brought into the organisation through Mr. Villard's influence is now out, the stockholders having unloaded on the public at the time of the incandescent lamp decision. This fact may account for the small rise in the stock at that time, and its subsequent sharp decline. It has been felt for some little time, especially by Drexel, Morgan and Co., the largest holders of the Edison stock, that a change in the executive department might be productive of good results; and although some who are in a good position to judge of the affairs of the Edison Company deny Mr. Villard's actual resignation, they generally admit that the next annual election in January, 1892, will be productive of considerable changes. Since the reorganisation that brought Mr. Villard to the front the company has lost the services of a large number of valuable men, among whom may be noticed Mr. E. H. Johnson, Mr. Frank Sprague, Mr. O. T. Crosby, Mr. H. Ward Leonard, Dr. Hutchinson, Mr. Jackson, and others almost equally well known. Apparently Drexel, Morgan and Co. are taking cognisance of this and similar facts, and are making ready to take action thereon.

The Gearless Motors.—Reports that have been floating around of late suggest that the gearless street railway motors brought out early this summer are not altogether successful. The Short motor has given good satisfaction in and about Cleveland, where it has been, for the most part, used, but most engineers seem to doubt its ability to operate over con-

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siderable grades with any degree of success. The Westinghouse gearless motor is said to have met about the same degree of success, the trouble in both cases being lack of torque. Indeed, from the size and general design of both these motors, it was rather difficult to see how both efficiency and high torque could be attained; it was not altogether evident where the power was coming from, so far as could be judged from the designs. I shall hope at a later date to give you some accurate tests of one or both of these gearless motors. The single-reduction gear motors have met with decidedly better success, in fact, hardly anything else is now being manufactured, although complaints are sometimes received of the same difficulty of too little torque that I have referred to in speaking of the gearless motors. There is, however, no good reason to expect that this difficulty will not be surmounted, as there is no particular trouble in designing single-reduction gear motors to give a good general result with a commercial efficiency probably somewhat greater than that of the old double-reduction gear machines.

The National Electric Light Convention.—Extensive preparations are now being made for the exodus of electricians to the National Electric Light Convention. The Edison and Thomson-Houston companies have made special efforts, and everything indicates that the Convention will be a success, and that the attendance will be large. My next letter will be from Montreal, and I shall hope to be able to give you some interesting news.

High Speed Traction.—Apart from things immediately electrical, a fact that will attract the attention of those interested in high-speed traction, whether electrical or otherwise, is the recent breaking of all previous speed records by a train over the Bound Brook route between New York and Philadelphia. One mile was run in 39⅘ seconds, equivalent to a rate of 90·45 miles per hour, while 10 miles were reeled off at an average speed of 43 seconds per mile, about 83¾ miles per hour. This speaks well both for the track and for the locomotive, which was of the Wootten pattern, provided with an exceptionally large and well-arranged furnace.

CORRESPONDENCE.

THE TELEPHONE MONOPOLY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR,—I have read with interest in your issue of Sept. 11th a letter from the Duke of Marlborough and your leading article upon the subject of the Telephone Monopoly. An experience through which I have myself just passed seems to me to be not unworthy of record. In April last I signed an agreement with the National Telephone Company, and at the same time obtained the permission of my landlord for the erection of a standard on the roof. Telephone wires run immediately in front, immediately behind and in fact on all sides of my house; yet it was only last week that I saw any attempt made to make the connection. In the meantime I had given notice to the Company that I considered four months ample time for the completion of the work and had withdrawn my order; for it appeared to me that if the management was so dilatory in respect to securing new customers, there was every probability that I should find it to be much worse when once I had paid my subscription.

Under these circumstances, therefore, you may readily imagine that I feel more than usually interested in the scheme proposed by the Duke of Marlborough; but I must confess that I do not quite understand how any new *company* is going to obviate the difficulties of existing corporations, except by obtaining parliamentary powers so vast and so arbitrary in their nature, as at once to create a monopoly of far greater stringency than any which has ever existed in this country; powers without which their efforts would be of no avail, but which it is hardly possible the House of Commons will be persuaded to grant.

I cannot help thinking that precisely the same arguments which were used in inducing the Government to take over the telegraphs are even more strongly applicable in the case of the telephones. In fact, I hold very strongly to the opinion that all matters in which the communications of the people are concerned should be under State management, being far too complicated and important for private enterprise.

Trusting you will not consider this letter too unimportant for insertion, I am, Sir, &c., J. F. W. S.

London, W.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

NOW READY.—"THE ELECTRICIAN" PRIMERS (38 in all. Vol. I., 20; Vol. II., 18), in two volumes. Price per volume 2s. paper covers, 2s. 6d. cloth; post free, 2s. 2d. and 2s. 9d. respectively. Single copies, 3d.; post free, 3½d. Prospectus on application to the Publisher.

TENDERS WANTED.—The Hove Commissioners are prepared to receive proposals from companies or persons willing to take over the undertaking and statutory powers for the supply of electrical energy in Hove vested in the Commissioners by the Hove Electric Lighting Order, 1890. Proposals are to be sent to Mr. Charles A. Woolley, town clerk, Town Hall, Hove, by October 26th. Further particulars appear in our advertisement columns.

——— The Bray Township Commissioners announce in our advertisement columns that they are prepared to receive tenders for the lighting of the streets of the township and Marine Promenade with electric light or gas for a period of one or three years. Tenders are to be delivered to Mr. Patrick MacDonnell, town clerk, not later than 11 a.m. on Monday, October 5th.

——— The Bradford Corporation invite tenders for lighting by electricity certain rooms in the Municipal Buildings. Plans and specifications may be seen at the office of Mr. W. T. M'Gowen, town clerk, Town Hall, Bradford, to whom tenders are to be forwarded by the 28th inst.

——— Tenders are required for the supply of electricity for lighting and power purposes to the Free City of Hamburg. Specifications and plans may be seen at the office of the Secretary of the Finance Deputation (Rathaus, I. Stock, Zimmer No. 34), or may be obtained on payment of 5s. Tenders are to be sent to the Finance Deputation by noon on October 10th.

DERBY INDUSTRIAL EXHIBITION.—During the past month an Industrial Exhibition has been held at the Drill Hall, Derby, where electrical appliances were exhibited by Messrs. John Davis and Son, of Derby, and the National Telephone Company. In the engine-room at the entrance were some four or five engines at work, and here Messrs. Davis exhibited an 18-unit compound-wound dynamo, driven by a Trent gas engine. This dynamo was used for lighting the hall and stage with incandescent lamps of from 16 to 500 c.p. A 2½-unit dynamo driven by another engine was used to work motors, for an automatic grain-weighing machine, an engraving machine, and a ventilating fan machine placed in the hall. On Messrs. Davis's stand in the hall were exhibited a large variety of telephones, mining bells and keys, portable, primary, and secondary battery lamps. Their exhibit obtained the gold medal, as was also the case last year at the Mining Exhibition.

THE ANDREWS' SYSTEM OF CONCENTRIC WIRING.—The wiring of the Waterloo Grain Warehouses, belonging to the Mersey Docks and Harbour Board, on the Andrews system has just been completed. The warehouses consist of three six-storey blocks, 80ft. wide, built along three sides of the Waterloo Corn Dock. The dynamo in connection with this installation is of Messrs. W. T. Goolden and Co.'s manufacture. The installation has been carried out to the specification of Mr. G. F. Lyster, the Dock Engineer, by Messrs. J. D. F. Andrews and Co., 41 and 42, Parliament-street, London, S.W., with the assistance of Mr. W. S. Boult, Assoc. M. Inst. C.E., 60, Castle-street, Liverpool, their sole agent for Lancashire and Cheshire.

KERITE INSULATION.—Under the name of Kerite an insulating compound, which has been used with success in the United States, is being introduced into this country. It is claimed that it withstands corrosion, and within a range of temperature extending to 200°F. it retains its flexibility and insulating properties. It is said to withstand exposure to the sun, and does not suffer from long storage; it is not attacked by marine borers or by white ants.

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FORTHCOMING BOOK ON TELEPHONES.—We are informed by Messrs. Whittaker and Co. that they are about to publish a practical handbook on telephones, dealing especially with telephone exchanges, by Mr. Joseph Poole.

CATALOGUES, &c.—GALLOWAYS (LIMITED).—We have received a very compact and well-got-up little *brochure*, being a miniature reprint of Messrs. Galloways' large catalogue. It contains a short account of the design of boilers and Galloway tubes, the testing, planing, riveting, flanging, and other numerous machines employed; a large number of sectional views of different systems of setting, &c. While most English boiler makers have stuck to the stupid description of the size of boilers by giving the nominal horse-power for which they are suited, Messrs. Galloway give the pounds of water evaporated per hour, the indicated horse-power at 20lb. of water, a table of pounds of water required for various sizes of cylinders at various pressures, and many other useful notes. A little more energy of this kind would enable the thoroughly reliable English types of boiler to compete more successfully with the American importations, since these have in many cases been chosen merely because the agents were ready to save their customers the trouble of selecting the right size, and giving them all possible information about setting, &c. Illustrations and particulars of a number of engines, pumps, and other machinery given.

——— THE CONSOLIDATED TELEPHONE CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).—This Company, which has had so large an experience in the manufacture of telephones, issues a fully illustrated list of the numerous patterns of transmitters and receivers, made under the Edison, Blake, Gower-Bell, and Hunning's patents, including many ingenious combinations for desk, domestic, and operators' use.

——— FELTEN AND GUILLEAUME.—This firm have sent us a pamphlet describing their wires and cables for telegraphy, telephony, torpedoes, and electric light, together with several kinds of junction and distributing boxes. The numerous systems of insulation are described, and an account is given of the Ferranti conductors.

——— MESSRS. BLAKEY, EMMOTT, AND CO. send us a catalogue of the electric light machinery and sundries sold by them.

BOOKS, &c., RECEIVED.

"Die Versorgung von Städten mit Elektrischem Strom." Edited by F. Uppenborn. (Berlin: Julius Springer. Munich: R. Oldenbourg.)

"Special and Atomic Energy." Part III., Heat. By Frederick Major. (London: Eyre & Spottiswoode. August, 1891.)

"The Durham College of Science Calendar, Session 1891-92."

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.

August 31, 1891.

14,663. A. SHIELS. Glasgow. Improvements in couplings for connecting electric wires.

14,702. H. HAUSER. London. Improvements in or connected with accumulators or secondary batteries.

September 1, 1891.

14,752. A. HEALD. London. Improvements in appliances for use with incandescence lamps.

14,754. B. P. SCATTERGOOD. London. New or improved apparatus for electrically indicating the over-heating of bearings.

14,764. W. P. THOMSON. Liverpool. Improvements in armatures for dynamo-electric generators and electric motors. (J. F. McLaughlin, United States).

14,768. W. P. THOMSON. Liverpool. Improvements in lightning arresters. (J. P. Freeman, United States).

14,780. B. B. TOYE. London. Improvements relating to telegraphy.

14,786. J. M. RILEY. London. Improvements in electrical combs.

14,790. W. P. ADAMS. Barnes. Improvements in electrical switches.

14,794. SIEMENS, BROTHERS, AND CO. (LIMITED). London. Improvements in percussion drills and other percussion tools worked by electricity. (Siemens and Halske, Germany).

14,796. C. D. ABEL. London. Electric meter for continuous or alternating currents, also applicable as speed indicator and speed regulator. (La Compagnie Anonyme Continentale pour la Fabrication des Compteurs à Gaz et autres Appareils, France).

14,800. H. H. LAKE. London. Improvements in and relating to electric metal working apparatus. (H. Lemp, United States).

September 2, 1891.

14,834. W. E. HEYS. Manchester. Improvements in and connected with electrically propelled vehicles. (C. Brown, France).

14,854. G. A. CANNOT. London. Improvements in materials for insulating electrical conducting wires, and for making carbons and incandescent filaments for electric lighting.

14,859. E. A. GIMINGHAM. London. An improvement in incandescent electric lamps.

September 3, 1891.

14,874. R. H. NEWINGTON and E. PRIDDLE. London. An improvement in electric light switches.

14,911. W. N. MARCUS. London. Telephone receiver supports. (Date applied for under Patents Act, 1883, Section 103, February 10, 1891, being date of application in United States).

14,912. W. N. MARCUS. London. Telephone mouthpieces. (Date applied for under Patents Act, 1883, Section 103, February 10, 1891, being date of application in United States).

14,916. T. W. ARNOLD. Birmingham. Improvements in magnetic separators.

14,920. K. SCHMAUS. London. Improvements in insulators for telegraph and other wires

September 4, 1891.

14,962. W. H. BROWN. London. Improvements relating to telephones.

14,967. G. STEINLE. London. Improved process and apparatus for extracting aluminium and its alloys by electrolysis.

14,987. SIEMENS BROTHERS and Co. (Limited), A. H. DYKES, and F. G. BAILY. London. Improved electrical drill.

September 5, 1891.

15,014. W. N. NAYLOR. London. An improved electric belt or band.

15,025. A. MCLEAN GORDON and E. K. IRWIN. London. An improved apparatus for propelling one or more imitation birds by electricity for shooting at.

16,050. E. A. LE SUEUR. London. Improvements in or connected with electrolysis.

15,051. C. P. STOVIN. London. Improvements in medical electric appliances.

15,052. C. P. STOVIN. London. Improvements in medical electric appliances.

September 7, 1891.

15,075. R. THOMPSON and H. S. PAYNE. Castletown, Isle of Man. An improved portable electric lamp.

15,094. H. TROTMAN. London. Improvements in the manufacture of leaves for lamp, candle, or electric light shades.

15,096. A. A. GOLDSTON. London. Improvements in feed mechanism in relation to arc lamps.

15,123. H. EDMUNDS. London. Improvements in or connected with systems of electric distribution wherein electrical storage batteries are used.

15,125. A. J. JARMAN. London. Improvements in electrical storage cells and elements therefor.

September 8, 1891.

15,162. M. A. HILLOCK and E. PENABLE. London. The improved medical electrode or electro-medical battery.

15,214. R. R. HARPER. London. Improved construction of telephone receiver.

15,240. SIEMENS BROTHERS AND COMPANY (LIMITED) and F. HIRD. London. An improvement in bobbins for dynamo-electric machines.

September 9, 1891.

15,268. J. H. THOMAS. Bristol. An improved miners' electric safety lamp.

15,299. W. R. LAKE. London. Improvements in electrical signalling apparatus, chiefly designed for police service. (The Newhaven Clock Company, United States.)

SPECIFICATIONS PUBLISHED.

1890.

12,440. DAY and DOWSING. Electric testing apparatus. (Price 1s. 1d.)

12,874. BONNE. (The Actien Gesellschaft Mix and Genest). Electric switch. (Price 8d.)

12,914. JARMAN. Electric switches. (Price 8d.)

12,957. DAVIES and TOURTEL. Electric lighting by coin freed apparatus. (Price 8d.)

12,958. DAVIES and TOURTEL. Producing electric light by insertion of coin. (Price 8d.)

13,123. HOOKHAM. Electricity meters. (Price 8d.)

13,357. SIEMENS. Electromotors. (Price 6d.)

14,624. ELMORE. Making metallic articles by electrolysis. (Price 8d.)

15,573. DOWN. Attaching electric fittings, &c. (Price 6d.)

15,635. HALL. Commuting alternating electric currents, &c. (Price 8d.)

15,643. HOPKINSON. Electric tramways. (Price 8d.)

15,819. JOHNSTONE. Electric dynamos, &c. (Price 8d.)

16,054. SERRIN. Electric batteries. (Price 8d.)

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16,055. SERRIN. Electric batteries. (Price 8d.)
16,156. JOHNSTONE. Electric conductors. (Price 8d.)
16,278. WALTON and EDMUNDS. Electrical conductors. (Price 4d.)
16,347. WILLANS. Electric clutches. (Price 6d.)
16,399. BOULT. Joray. Electric deposition of metals. (Price 8d.)
16,556. THOMPSON. (Moore). Holding telephone receivers, &c. (Price 8d.)
17,402. COOK and others. Electrical conductors. (Price 8d.)
17,611. ABEL. (Messing). Electrical push button for signalling circuits. (Price 6d.)
18,896, ELMORE. Making copper tubes, &c., by electrolysis. (Price 8d.)
19,232. GARROW and FORWELL. Coin freed dynamo meters. (Price 8d.)

1891.

2,612. MERCADIER. Telephone receiving instruments. (Price 8d.)
6,847. LINVILLE and HETTMANSPERGER. Printing telegraphs. (Price 2s. 10d.)
7,204. KINGSLAND. Electric alarms. (Price 8d.)
7,762. VAN DEPOELE. Reciprocating electric engines. (Price 8d.)
9,073. MUNSIE. Electric railways. (Price 8d.)
11,133. LAKE. (The Crocker-Wheeler Electric Motor Company). Dynamo-electric machines, etc. (Price 8d.)
11,473. LAKE. (Tesla.) Electro-magnetic motors. (Price 8d.)
11,746. VAN HOUTEN. Telegraphic apparatus. (Price 11d.)
12,069. FITZPATRICK. (Schöller and another.) Electrodes for secondary teries. (Price 6d.)
12,243. KAISER. Magnetic compasses. (Price 8d.)

COMPANIES' MEETINGS & REPORTS.

Direct Spanish Telegraph Company (Limited).

The following is the Directors' report for the half-year ended June 30, 1891, to be presented at the general meeting of shareholders, to be held at Winchester House, Old Broad-street, E.C., on Tuesday, September 29, 1891 :—

The annexed accounts for the half-year ended June 30, 1891, show, after providing for debenture interest, a balance to the credit of profit and loss of £5,525. 16s. 10d.

The traffic receipts show a decrease of £1,620. 10s. 6d., as compared with those for the corresponding half-year of 1890. The falling off in the receipts is principally attributable to the comparative failure of the early fruit crop in Spain, owing to the severe frost, and to the iron ore trade having been adversely affected by the strikes in England and at Bilbao.

The working expenses are £284. 11s. 9d. in excess of those for the corresponding period of last year.

With the exception of the interruption of the Barcelona cable from April 3rd to 14th, the Company's cables and the land-lines in connection with them have continued in good working order throughout the half-year. The entire cost of the repairs of the Barcelona cable, amounting to £1,695. 1s. 2d., has been paid out of the "Contingencies Account."

Of the balance of profit and loss, £2.500 have been put to the reserve fund (which now amounts to £25,928. 7s. 8d.), leaving a balance of £3,025. 16s. 10d. Out of this amount the Directors recommend the payment of the dividend at the rate of 10 per cent. per annum on the Preference shares, and a dividend at the rate of 5 per cent. per annum (free of income tax) on the ordinary shares. This will admit of a sum of £270. 4s. 10d. being carried to the "Contingencies Account." The dividend warrants will be issued on October 1, 1891.

Brush Electrical Engineering Company (Limited).

The following is the second annual report to be presented to the shareholders at the general meeting of the Company, to be held at Cannon-street Hotel, London, on September 25, 1891, at 3 o'clock p.m. :—

The Directors beg to submit the balance-sheet and profit and loss account for the year ended June 30th last.

The profit and loss account shows a gross profit of £42,712. 8s. 10d., inclusive of the amount brought forward from last account, but exclusive of any profit derivable from the City of London Electric Lighting Undertaking. After deducting all standing charges, &c., maintenance of plant, buildings, and patents, and interest on debentures, there remains a balance of £19,354. 2s. 1d. It is proposed to apply £630 to reduction of preliminary expenses, and to reduce property, patents, and goodwill account by £3,000. An interim dividend, absorbing £4,199. 15s. 2d. has already been paid upon the Preference shares for the six months ended December 31st last, and it is proposed to apply £4,199. 15s. 2d. to the payment of a further dividend upon these shares, making up the full preferential dividend at the rate of 6 per cent. per annum. The Directors further recommend that a dividend be paid on the ordinary shares of the Company at the rate of 6 per cent. per annum for the half-year ended June 30th last, and that the balance of £306. 11s. 5d. be carried forward to next account. It is proposed to make the dividends on both the Preference and the ordinary shares payable on October 1st next.

The accounts include the returns from the Australasian branch, made up to the 30th April last. The business of the branch is now established on a satisfactory basis, and the result of the working shows a small profit.

The capital account has during the year been increased by £5,000, being the amount of fully paid shares issued to the Australasian Company in completion of the purchase of their stores and other assets in Australia.

The property account stood at the date of the last balance-sheet (after writing off £3,000) at				£294,400	8 10
During the year the account has been increased by—					
Proportion of shares issued to the Australasian Company, and cost of establishing branch	£1,918	10	6		
Additions to buildings, plant at Loughborough and other places ...	5,226	2	4		
Expenditure on new patents and developments	564	2	1		
				7,708	14 11
				£302,109	5 9
The account has been reduced by—					
Sales of properties, amortization of leases, and proportion of compensation received from South-Eastern Railway	£13,294	3	3		
Amount this year included in balance-sheet of foreign and colonial branches, pages 8 and 9	22,544	2	8		
				35,838	5 11
The account now stands at				£266,270	19 10

During the past year sums amounting to £21,070. 18s. 1d. were expended upon the City of London Electric Lighting Undertaking, arrangements having been made with a provisional Company called the City of London Electric Lighting (Pioneer) Company for the carrying on of the work. Since the closing of the books the whole of the interests of the Brush Company in the City of London Electric Lighting Undertaking have, with the consent of the Board of Trade and the Commissioners of Sewers, been transferred to a larger Company called the City of London Electric Lighting Company. As, however, the transfers were not completed until August 21st, no profits on the large amount of work done have been included in the profit and loss account to June 30th.

In consideration of this transfer the Brush Company has received contracts for the equipment of the central stations, amounting in the aggregate to over £300,000, to be executed by instalments as specified by the City Company. A satisfactory profit will accrue from the carrying out of these contracts, and an amount of about £53,650 is now payable to the Brush Company on account, in addition to £25,700 already received.

A strip of land adjoining the Lambeth Works has been sold to the South Eastern Railway Company in consideration of the payment of £6,500. A portion of this amount has been applied to reduction of property account, and the balance has been placed to a reserve account to meet the expenses caused by the disturbance. The main factory premises will not be affected by this sale of land, but the present office accommodation of the Company will be much curtailed, and the Board have decided to take the opportuuity of removing the Head Offices to the City.

The Bournemouth undertaking, consisting of provisional order, land, buildings, and plant, has been transferred to a local company in consideration of the sum of £17,275 which has been paid partly in cash and partly in fully paid shares of the Company, and the stores have been sold for cash at a valuation. As part of the arrangement this Company has guaranteed a minimum dividend of 5 per cent. per annum for three years upon the capital of the Company, not exceeding £30,000. The profit on the sale has been placed to reserve account.

The Austro-Hungarian business continues to increase and to give satisfaction, and the new factory at Vienna will shortly be completed. The negotiatiens for a rearrangement of the Company's interest in the business are still pending.

The volume of the Company's business in the manufacture and installation of electrical apparatus and in the construction of steam engines, and of rolling stock generally, continues to increase, and the prospects for the current year are encouraging. Besides the work to be done for the City Company several other important contracts have been secured which should result in profit to the shareholders.

The large amount of work in hand and in view has demonstrated the wisdom of acquiring and extending the Falcon Works, as without these additional manufacturing facilities the Company would not have been able to undertake the carrying out of these large central station contracts.

Owing to pressure of other engagements, Lord Thurlow felt compelled to resign his seat at the Board, and the Chairmanship of the Company, and his Grace the Duke of Marlborough has succeeded him as Chairman. The Directors also regret the retirement from the Board of Mr. John S. Sellon, on account of his health. Mr. E. Garcke, formerly manager and secretary, has been appointed Managing Director. The Duke of Marlborough and Mr. Sanderson retire by rotation, and offer themselves for re election. Messrs. Cooper Brothers and Co., the auditors, offer themselves for re-election.

NEW COMPANIES, STATUTORY RETURNS, &c.

ANGLO-AMERICAN CONSTRUCTION COMPANY (LIMITED).—This Company was registered on September 11, 1891, with a capital of £100,362, divided into 10,000 £10 shares, 12 £1 shares, and 7,000 1s. shares, by Norton and Co., 57½, Old Broad Street, E.C. The objects are :—To undertake in any part of the world the construction, equipment, completion, maintenance, or working and carrying on, of any railway, tramway, dock, harbour, water-works, gas-works, system of electric lighting, or other work of a public, private, or commercial character. The numbe of

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Directors is not to be less than six nor more than eight. Qualification, £500.

MARLAND, NORTH DEVON, BRICK COMPANY (LIMITED).—This Company was registered on September 8, 1891, with a capital of £3,C00, in £10 shares, by Crowders and Vizard, 55, Lincoln's Inn-fields, W.C. The objects are :—To manufacture and deal in bricks, lime, cement, pottery, electric insulators, tiles, &c. The number of Directors is not to be less than three nor more than seven. Qualification, £50.

MID-DEVON BRICK COMPANY (LIMITED).—This Company was registered on September 12, 1890, with a capital of £25,000 in £5 shares, by Waterlow Brothers and Layton (Limited), Birchin-lane. The objects are : —To acquire and carry on the business of brick and tile manufacturers, and to produce and use electricity, magnetism, and other power. The number of Directors is not to be less than 4 nor more than 7, the first being C. Green, T. V. Cooke, C. Stanbury, and S. Stanbury.

MORECAMBE ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—This Company has been formed for the purpose of supplying electric light and motive power in Morecambe and district, with a capital of £15,000, divided into 50 founders' and 14,950 ordinary shares of £1 each, and applications are now invited for these shares. After 7 per cent. has been paid on the ordinary shares, the surplus is to be divided one-third to founders, one-third to reserve, and one-third as further dividend on the ordinary shares.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the past week were £4,430.

CITY AND SOUTH LONDON RAILWAY COMPANY.—The traffic receipts of this Company for the past week amounted to £664.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended September 11th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £2,971.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, September 9.	Price Wednesday, Sept. 16.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Sept. 16. Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
£1,800,980	Stock	12/0	Anglo-American	47½ 48½	48½ 49½	5 11 1	Jan., Apr., July, Oct.	49	48½
£2,849,510	Stock	24/0	Do. Preferred	86½ 87½	87 88	6 2 2	,, ,,	87½	87
£2,849,510	Stock	5/0	Do. Deferred	12½ 13½	13½ 14½	..	.. ..	14½	13⅝
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99 102	99 102	3 18 5	January and July ..	100⅛	..
180,000	£10	5/0	Brazilian Submarine	11⅞ 12½	11⅞ 12½	6 18 9	Mar., June, Oct., Dec.	12⅛	11⅞
£69,200	£100	5%	Do. 5 per Cent. Bonds	99 102	99 102	4 18 0	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107	103 107	4 18 6	June and December	..	..
£7,716,000	$100	7%	Commercial Cable Capital Stock	107 109	117 119	5 17 8	April and October ..	114⅛	110⅛
16,000	10	8/0	Cuba Submarine	10 11	10 11	7 5 6	February and August	10⅛	10⅛
6,000	10	10%	Do. Preference 10%	16½ 17½	16½ 17½	5 14 3	,, ,,	..	..
12,931	5	3/2½	Direct Spanish (£4 paid)	3½ 4	3½ 4	7 0 0	April and October..	3⅝	..
6,000	5	10%	Do. Preference 10%	9½ 10½	9½ 10½	4 15 3	,, ,,	..	..
60,710	20	3/6	Direct United States	10½ 11½	10½ 11½	6 5 10	Jan., Apr., July, Oct.	11	..
400,000	10	5/6	Eastern	14⅜ 14½	14½ 14⅝	4 9 8	,, ,,	14½	14½
70,000	10	6%	Do. 6 per Cent. Preference	15 15⅜	15 15⅜	3 17 6	,, ,,	15½	..
£1,200,000	Stock	6%	Do. 4 per Cent. Mort. Debenture Stock	107 110	107 110	3 12 9	May and November	108½	107
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	107 110	4 10 11	February & August	107½	..
250,000	10	2/6	Eastern Extension	14⅞ 15½	14⅞ 15½	4 12 7	Jan., Apr., July, Oct.	15½	14⅞
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock	105 108	105 108	3 14 1	February & August	107⅛	107½
£85,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	104 107	104 107	4 13 6	January and July ..	104⅜	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	102 105	102 105	4 15 3	,, ,,	..	..
180,227	10	4/6	Globe Telegraph and Trust	9⅜ 9⅞	9⅜ 9⅞	5 6 4	Jan., Apr., July, Oct.	9⅞	9⅜
180,042	10	6%	Do. 6 per Cent. Preference	14⅞ 15½	14⅞ 15½	3 19 4	,, ,,	15½	14⅞
150,000	10	5/0	Great Northern	18½ 19	18⅞ 19⅛	4 8 4	Jan., April, and July	19	18⅞
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883 xd	104 107	104 107	4 13 6	March & September	..	..
17,000	25	37/6	Indo-European	41 43	41 43	5 15 3	May and November	..	..
33,348	10	5/0	London Platino-Brazilian	6½ 7⅛	6½ 7⅛	6 0 0	,, ,,	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures xd	104 107	104 107	5 12 2	March & September	..	..
9,000	8	4/0	Reuter's	8 8½	8 8½	4 14 1	April and October..	..	..
3,881	£100 Cert.	£1	Submarine Cables Trust 6%	120 125	120 125	4 16 0	,, ,,	121½	..
15,609	10	6/0	West African Telegraph	8 9	8 9	5 11 1	January and July ..	..	..
£231,400	100	5%	Do. 5 per Cent. Debentures xd	96 99	96 99	5 1 0	March & September	99	..
80,000	10	2/0	West Coast of America	3½ 3¾	3½ 4	..	January and July ..	3¾	..
£150,000	100	8%	Do. Debentures 8% 1902	97 102	97 102	7 16 10	June and December	..	..
88,321	10	9d.	West India and Panama	1⅜ 2	1⅜ 2	..	..	1⅜	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	9½ 10½	9⅝ 10½	5 17 1	May and November	10½	9⅛
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8 9	8 9	6 13 4	,, ,,	8⅜	..
61,683	15	9/0	Western and Brazilian	10⅜ 11½	10⅜ 11½	6 13 4	,, ,,	11⅛	11⅛
30,364	7½	1/6	Do 5 per Cent. Cumulative Preferred	6½ 7	6½ 7	5 7 8	,, ,,	7	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	4½ 4⅞	4½ 5	..	..	4⅞	4⅝
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	102 105	102 105	5 14 3	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	102 105	102 105	5 14 3	,, ,,	..	..
£1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	117 122	5 14 9	May and November	..	..
£173,100	£100	6%	Do, per Cent. Sterling Bonds xd	98 102	98 102	5 17 8	March & September	..	..
			TELEPHONES.						
£24,850	14/0	0/5½	Consolidated Telephone Const. & Maintenance.	⅜ ½	7/16 ½	..	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid)	5/16 5/16	5/16 5/16	6 3 11	Yearly	..	..
438,984	5	3/6	National	4⅛ 4⅜	4⅛ 4⅜	6 0 4	June and December	4⅜	4⅛
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½ 13½	12½ 13½	4 8 11	,, ,,	13½	..
15,000	10	6%	Do 6 per Cent. Cumulative 2nd Pref (£8 pd)	12½ 13	12½ 13	3 14 1	,, ,,	..	..
350,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd)	106 108	106 108	4 3 4	.. ..	107	106½
58,000	5	1/0	United River Plate	2 3	2½ 3½		January and July ..	..	..
£146,370	tock	5%	Do. 5 per Cent. Debenture Stock	85 95	85 95	5 5 8	,, ,,	..	..
			ELECTRICITY SUPPLY COMPANIES.						
1,000	£10	..	City of London Electric Lighting (£4 paid, £10 Sh.)	..	4 4½	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	4⅛ 5	4⅛ 5	..	..	..	..
5,322	£5	..	House to House Electric	..	4⅛ 5	..	..	..	..
30,000	£5	..	Liverpool Electric Supply (£3 paid)	..	2⅜ 2⅝	..	..	..	..
111,000	5	..	London Electric Supply	1⅜ 2	1⅜ 1⅝	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	9½ 10½	9⅜ 10½	..	..	10⅛	9⅛
7,730	£5	3/6	St. James' and Pall Mall	6⅜ 7½	8 8½	—	..	8½	7½
..	..	7%	Do. 7% Preference	4½ 4⅝	4½ 5	—	..	5	4⅝
42,853	5	..	Westminster Electric Supply (£5 paid)	5¼ 5⅜	5¼ 6	..	..	5⅜	5¼
			ELECTRIC MANUFACTURING, &c., COMPANIES						
77,978		..	Brush Electrical Engineering	2⅜ 2⅝	2⅜ 3⅛	..	..	3	2⅜
69,996		6%	Do. 6 per Cent. Preference	1⅜ 2⅛	1⅜ 2⅛	5 12 11	June and December	2⅛	1⅜
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	4⅜ 5⅛	4⅜ 5⅛	6 7 3	January and July ..	5⅛	5
17,130	5	..	Edison and Swan United	..	..	..	—	..	..
45,000	10	6%	Electric Construction	4⅛ 4⅜	4⅛ 5	..	—	4⅛	4⅛
70,000	2	10/0	Elmore's Patent Copper Depositing	4⅛ 4⅜	4⅛ 4⅜	..	—	4⅛	4
20,000	5	..	Fowler-Waring Cables (£4 paid)	2 3	2 3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	19½ 20½	19½ 20½	4 17 7	February & August	20½	19½
£300,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	104 106	104 106	4 4 11	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	7⅛ 8½	7⅛ 8½	11 15 3	.. ..	..	..
11,334	£10	5/0	Do. Preference	9½ 9⅝	9½ 9⅝	8 4 1	.. ..	..	..
78,949	5	2/1½	Swan United (£3. 10s. paid)	4⅜ 5	4⅜ 5⅛	6 13 4	May and November	4⅛	..
37,350	12	12/0	Telegraph Construction and Maintenance	42 44	42 44	5 9 3	March and July.....	43½	42½
£150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	102 105	102 105	4 15 3	January and July ..	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£2. 10s. paid)	..	2⅛ 2⅜	..	.. ..	..	..
—	£5	..	Do. Preference (fully paid)	..	3⅛ 4	..	.. ..	..	..
			RAILWAYS.						
50,000	£10	..	City and South London Railway	3 5	3 5	—	—	..	..

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THE ELECTRICIAN:

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NOTES.

The Convention of the National Electric Light Association, which was held during this month at Montreal, appears to have been of a thoroughly commercial and practical character. Discussions on C.-G.-S. units and theories of magnetism are not to be found at this gathering, but manufacturers, and managers of supply stations were well to the fore, and the Papers which we have glanced over are full of practical suggestions and records of experience. We propose to publish abstracts of some of them, but a great deal of the matter can only have an outside interest to our readers, since the conditions differ so largely from our practice and requirements. A considerable discussion took place on the rates to be charged for the intermittent supply to motors for lifts. One company charges 25 cents and another 10 cents for a thousand watt-hours, but both charge $60 per horse-power year. Coal costs $2.65 per ton at the latter station, and the "indicated consumption is not more than two pounds per horse-power hour." The term "indicated consumption" requires a little explanation: if it refers to consumption per indicated horse-power, we are not much wiser; for in another Paper we find that the ratio of the electrical horse-power at the dynamo terminals to the indicated horse-power of the engine ranged from 70·3 per cent. to 77·5.

The frank way in which these station managers discussed their customers is rather amusing. "The charges to customers have been, according to my experience," said one of these gentlemen, "regulated with what the customers were willing to pay for the service." A former speaker had alluded to rebates. "The Paper," he continued, "speaks of the rebates costing only one-hundredth of 1 per cent. The rebates do not cost us that, as we only give rebates back to men who kick so outrageously that we cannot get rid of them." Rebates of this kind, and, perhaps, also the outrageous kicking which is a necessary antecedent, are developments of transatlantic civilisation with which we are not familiar. One-hundredth of 1 per cent. is certainly not worth any very violent exertion of this kind.

The correspondence in *The Times* on the London telephone service still continues—a not surprising phenomenon when we remember the peculiarly "live" subject under discussion, and the dead season of the year. Whether or not the Act of 1882 adversely affected the progress of electric lighting in this country can only interest social economists. But the present unsatisfactory condition of telephonic communication in London, the possibility of its improvement, and the probability of £10 rentals are matters which appeal to the public generally. Hence copious correspondence and innumerable suggestions.

The question at issue, as we have said before, is a very plain one. Granted that having got the telephone the most sensible thing to do is to make the utmost use of it, it cannot be denied that this ideal is not even approximated in London. For this state of affairs three remedies are suggested. The National Company, at any rate until quite lately, looked upon the multiplication of overhead wires which would result from complete metallic circuits and lower rates as not to be thought of, owing to parochial prejudices. It, therefore, endeavoured to satisfy its subscribers by concentrating its wires upon a few exchanges, and re-running all its lines in a more modern manner. These efforts have had but a small measure of success. The New Company proposes numerous small exchanges, the Mann system of switching and twin-wire circuit as *the* remedy for the present situation. The public, if we may take the daily press as a guide, incline to a Post Office monopoly. It is difficult to resist the conclusion that there is much to be said for this view.

The statement which we made in a recent leading article that no telephone system could be considered of much account unless complete, has been met with the ingenious argument that the National Company would be sure to bring down their rental to the £10 level to kill competition; hence all those who now use the telephone could subscribe to both systems for the same price as they now pay to one. This might be so; but in that case the unfortunate telephone subscriber, it seems, will be exactly where he was before, £20 a year still being exacted of him if he is desirous of conversing with anyone and everyone in the Metropolis. Seriously speaking, however, a telephone company competing in London would be certain ultimately to amalgamate, crush or be crushed; and, pending that consummation, something like telephonic chaos would prevail.

It is not easy to find any reason for the complacency with which Joule's equivalent is accepted in the scientific world, or the small attention which is paid to new determinations of it. The mechanical equivalent of heat appears to us to be one of the most important physical constants. Violle, Marks, Rowland, Anderson and Cowper, and Miculescu have made

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fresh determinations, but there is little indication that confidence has been shaken in the well-known 772. The last of these determinations, as we observed in commenting upon it in a recent issue, rather tends to confirm JOULE's figure; being equivalent to 772·3, while Prof. MARKS obtained 772·81. In another column will be found an account of a determination by M. D'ARSONVAL, which is, perhaps, more interesting, on account of the details and methods employed, than important as throwing any fresh light on the accuracy of JOULE's value.

THE principle employed by M. D'ARSONVAL in determining the mechanical equivalent of heat was suggested some time ago by Prof. S. P. THOMPSON in his lectures, but has not been otherwise published. He proposed to hang a cylindrical copper vessel containing mercury by a bifilar suspension between the limbs of a magnet, which would be kept in rotation about a vertical axis. The magnetic field would drag round the cylindrical vessel through an angle which could be measured in the usual way, and the heating of the vessel and the mercury contained in it would be measured by fitting a glass tube to the top, thus making it practically the bulb of a thermometer.

THE reticence of lampmakers on the important question of the life of their lamps is very natural—they do not want to commit themselves to any rash promises. It is no use concealing the efficiencies, for these can be determined in a few minutes. But it seems that the Sunbeam Lamp Company might make some modest claim to a life for their lamps, for even a very short life would allow them to compete, much more favourably than is generally believed, with ordinary glow lamps. We have no definite information as to the life of Sunbeams; we made inquiries some months ago, and could only learn, what indeed is very apparent, that they are rather liable to blacken and thus to fall in efficiency. We have, therefore, reckoned up the comparative cost of these large lamps with ordinary glow lamps, with the view of finding out what length of life must be demanded of them if the total cost is to be the same in the two cases.

TAKING 500 c.p. for 1,000 hours, we should have, in the case of small lamps, to pay £59 for current (at 7d. per unit), and if 8-c.p. lamps are used the renewals, at 3s. 9d., would come to about £12, making a total of £71; or if 16-c.p. lamps are used—and this would be a more fair comparison—the renewals would come to £6, making a total of £65. Taking a 500-c.p. Sunbeam of the high efficiency class, at two watts per candle, the cost of current would be £29 for 1,000 hours, leaving £36 for lamp renewals, to bring the total to the same as that of the 16-c.p. lamps. This allows, at the price quoted in the list before us, 33 renewals, or a life of only 30 hours. But two watts to the candle is too good to be true, though it may represent the state of the lamp when new. Suppose, however, it falls from two watts to six watts, with a mean of four watts to the candle, the cost of current would be double the above figure, viz., £58, leaving £7 for renewals, in order to bring the total cost up to that of the 16-c.p. lamps. This would allow 6·35 renewals, or a life of 157 hours. We have only taken the 500-c.p. lamp at random, but it certainly leaves room for a modest claim on the part of the makers, who, strange to say, make no claim of the kind whatever.

Kilkenny.—At the last meeting of the Town Council it was resolved to introduce the electric light into the town.

Montreal.—The street lighting of Montreal, which already requires nearly 1,200 arcs, is shortly to be further increased.

The Faraday Centenary.—The Physical Society of St. Petersburg held a sitting on Tuesday evening last in honour of the centenary of Faraday.

Telephones in Winnipeg.—The town of Winnipeg possesses a telephone exchange which has now over 750 subscribers, being about one to every 36 of the population.

Metropolitan Electric Supply Company.—This Company now has its mains laid and ready to supply current in some 250 streets in the W.C., W., and N.W. districts.

Glasgow.—It is in contemplation to send a deputation from the Town Council to Frankfort to obtain information on the application of electricity to lighting and traction.

Sofia.—The tender of Ganz and Co., of Budapest, has been accepted for lighting Sofia by electricity. The installation, which will cost £80,000, is to be completed within two years.

The Oerlikon Works.—M. Emile Huber, of Zürich, has joined the Board of the Oerlikon Maschinenfabrik, and Mr. C. E. L. Brown will sever his connection with the firm at the end of the present month.

Bedford.—After a lengthy debate at a public meeting, convened last week by the Mayor, it was resolved that the Corporation should retain the power of carrying out the electric lighting of the town in their own hands.

Japanese Cables.—The telegraph cable between Nagasaki and Tsushima, in Japan, belonging to the Great Northern Telegraph Company, is about to be taken over by the Department of Communications of the Japanese Government.

Calcutta.—The Howrah Bridge, across the Hooghly, at Calcutta, has been lighted experimentally by the electric light. The effect is said to be most satisfactory. It is contemplated to extend the lighting to the docks at Kidderpore.

Canadian Electric Lighting Statistics.—There are at the present time in Canada some 150 central stations in operation, with about 12,000 arcs and 60,000 incandescents. Of these plants about 25 per cent. are operated by water-power.

Transmission of Power to Heilbronn.—Work was commenced on the installation for transmitting power from Lauffen to Heilbronn for the purpose of lighting the latter town on the 7th inst., and it is expected to be completed by December 1st.

The Telephone in Melbourne.—The City of Melbourne possesses a telephone exchange provided with a switch board capable of accommodating 2,600 subscribers. At present the number of subscribers to the exchange amounts to over 1,800.

Hanover.—The Municipal Central Station having now supplied current to private consumers for six months, a step is to be made towards lighting the public streets by electricity. Arc lamps are to be used for the purpose, the work being entrusted to the Allgemeine Elektricitäts Gesellschaft.

The Electrical Utilisation of Water-Power.—An Anglo-Swiss syndicate has been formed for the purpose of utilising the power of the Rhine near Laufenburg for the electrical transmission of power. It is intended to make a canal about one mile long, and it is estimated that some 7,000 H.P. will be available.

The Schuckert Trolley.—A very simple and apparently efficient trolley is used on the Schuckert overhead conductor electric tramway at the Frankfort Exhibition. It consists of an ordinary coiled conical spring, one end of which is fixed to the roof of the car, while the other end bears a socket for the trolley rod.

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The Chicago Exhibition.—The Vienna Council of Ministers has refused to grant any subsidy to manufacturers who propose to show their goods at the Chicago Exhibition. On the other hand, it is stated that the Japanese Government proposes to spend the sum of £140,000 in connection with the Chicago Exhibition.

Telephone Trunk Wire Extensions in Germany.—The telephone trunk line connecting Ulm and Stuttgart (50 miles) has been completed, and will start working immediately. The line between Stuttgart and Rottweil is to be taken in hand at once, and that joining Tubingen to the general network will follow in the spring of next year.

The Salzburg Central Station.—From January 1st to August 31st of this year the Salzburg electric works supplied 1,386,252 lamp-hours, against 882,754 for the corresponding period of last year, an increase of 57 per cent. The electric lift at the Mönschberg, which completed its first year of working on August 9th, has carried up to that date 150,293 persons.

New Mexican Customs Tariff.—The Mexican *Diario Oficial* is publishing the new Customs tariff which is to come into operation on November 1st next, and from the particulars given it would appear that copper wires for electric lighting purposes will again be admitted into the country free as hitherto. Telegraph and telephone wires are also to be admitted free of duty.

The American Rubber Syndicate.—According to the financial papers, the great American rubber syndicate has failed, as so many previous combinations have done, from sheer inability to go on buying the quantities necessary to maintain its control. It was unable to borrow more money to purchase the new crop now coming into Para, and the great enterprise has proved a fiasco.

A Lead Alloy for Accumulator Plates.—The following lead alloy for accumulator plates is proposed by a M. Worms. It consists of 945 parts of lead, 22 of antimony, and 13 of mercury. The lead is melted first, and the antimony added, the mercury being introduced as the molten mass is run into the mould. The result is said to be an alloy of lead which can be easily split up into comparatively thin sheets.

Arc Lighting in Toronto.—The Toronto Electric Light Company was formed in September, 1883. It now lights the entire city, supplying current by means of 48 dynamos to 1,700 2,000 c.p. arcs, 1,500 of which are used in the streets. The steam plant consists of thirteen 100 H.P. Polson boilers, four 500 H.P. high-pressure condensing engines, and four 500 H.P. compound condensing engines, all of the Brown-Corliss type.

Cologne.—Distribution from the new central station is on the alternate-current transformer system, the cables being buried in asphalte poured into wooden conduits. Herr Hegener, the director of the Cologne station, is greatly in favour of transformers as against accumulators, and he asserts that the efficiency of the accumulators in the Darmstadt station has dropped from 62·1 to 57·8 per cent. within a year.

Church Lighting.—The London Electric Supply Corporation, who have gratuitously supplied St. Nicholas Church, Deptford, with the electric light for the last three years, have given notice that they can no longer do so unless arc lamps are substituted for incandescent lamps. As the electric light has been found preferable to gas in many ways, the churchwardens have resolved to make the change at a cost of 100 guineas.

The Cavalry Telegraph.—During the autumn manœuvres of the Austrian cavalry a telegraphic equipment, specially designed for field use, was tested, and gave complete satisfaction. The apparatus and batteries are placed in two small boxes, one of which can conveniently be carried on each side of a saddle. A line of 20 kilometres was laid in two hours. Each of the 41 regiments taking part in the manœuvres was provided with one of these portable sets of apparatus.

The Magnetic Survey of the United Kingdom.—In the last report of the British Association Committee on the Reduction of Magnetic Observations, it is stated that the magnetic survey of the United Kingdom, started on their own account by Profs. Rücker and Thorpe, proceeds rapidly under their superintendence. Messrs. Gray and Watson are at work in Ireland and Scotland respectively; and observations are made at more than 600 stations all over the British Isles.

The Bandsept Accumulator.—The accumulator invented by M. Bandsept is being introduced by the Franco-Belgian Lighting Apparatus Company. The electrodes are formed of a compressed powder, which is saturated during the process of compression by substances reduced to a gaseous state. The powder is thus impregnated, and becomes solid under continued pressure. The Company is about to carry out a system of electric lighting on the smaller lines of railway by means of this accumulator.

The Gutmann Electric Heater.—This heater consists of an electro-magnet whose laminated magnetic circuit is closed through a grate. The alternating current circulating through a coil wound round the laminated core establishes at its poles a field of rapidly varying intensity, which finds a path from one pole to the other through the grate, made of wrought or cast iron. The latter, not being laminated, becomes heated rapidly. The heat radiated is readily applied for heating or cooking purposes.

Dufftown.—At a public meeting recently held to consider the question of the Police Commissioners purchasing the present gas works and erecting new works, it was unanimously agreed to grant power to the Commissioners to employ a competent electrician to examine and report upon the practicability and probable cost of introducing electric light. It is understood that the waters of the Dullan or Fiddich would be used as the motive power for generating the electricity should the project be gone on with.

Gutta-Percha Forests.—The valley of the Orinoco, which is connected in such a peculiar manner to the River Negro by the Casicuiare, has been found to contain not only immense virgin india-rubber forests, the trees of which are said to yield a rubber superior to the best Para, but also trees of the order Sapotaceæ. Amongst the various gums obtained by explorers in the upper reaches of the river, some have been found by experts to be very similar, if not identical, with the product of the *Isonandra Percha* and *Dichopsis Gutta* of the Malay Archipelago.

Charterhouse Science and Art Schools.—The winter session of this, one of the largest science and art schools in the United Kingdom, will commence on Saturday, September 26, 1891, under the presidency of the Rev. Henry Swann, M.A. During the late session upwards of 1,100 students, mostly elementary teachers, availed themselves of the privileges afforded by this institution, and of this number nearly 800 presented themselves for examination, and were successful in obtaining a large number of certificates awarded by the Science and Art Department of South Kensington. Instruction of a practical character is given in most of the sciences at a very nominal fee.

The Electric Defences of the Thames.—The War Office authorities issued orders last week for an important series of combined artillery and submarine mining operations to be carried out at Sheerness to test the efficiency of the scheme of defence for the entrances of the Rivers Thames and Medway. The operations include night attacks on the forts. Telephonic communication has been established between Garrison Point and Grain forts for the purposes of the operations, and powerful electric search lights, to command the estuary of the Thames and Medway, have been erected on Fort Grain, on No. 1 Bastion, Sheerness lines, and at Barton's Point, near Sheerness.

The Frager Meter.—At the fortnightly meeting of the Lighting Committee of the Liverpool City Council, held on the 21st inst., the electric inspector (Mr. Yeaman) reported the completion of a series of tests undertaken with a view to the adoption of a standard meter with which to test the consumers' meters. The meters tested included those of the Hookham, Hartmann, and Braun, Frager, Richard Frères Laurence Scott and Co., Aron, and Ferranti types. The committee approved of the adoption of the Frager meter as supplied by Mr. R. P. Wilson, London, as a standard, and passed an order for the purchase of the instrument.

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Hanover-square School of Electrical Engineering and Submarine Telegraphy.—The manager of this school, Mr. L, Drugman, M.I.E.E., informs us that as the result of the examination for the vellum certificate of the school, held in August. the following gentlemen have obtained the certificate in Electric Lighting and Power Transmission :—Messrs. G. Boa, J. L. Chambers, W. M. Hartin, G. Johnson, and W. B. Lock. This examination was conducted by Mr. Gisbert Kapp, M. Inst. C.E., M. Inst. E.E., and consisted of a Paper on Mechanical Engineering, a Paper on Electrical Engineering, a *viva-voce* and Practical Examination, and Drawing. All these students belonged to the advanced class. Instructor, Mr. Charles Capito, M. Inst. M.E., M. Inst. E.E.

Electric Traction on the South Staffordshire Tramways.—At a general meeting of the South Staffordshire Tramways Company, held at Darlaston on Thursday last week, the Chairman (Mr. Carruthers Wain) stated that arrangements were almost completed with a company to work the principal part of the tramway undertaking by means of overhead wires, the electric company to equip, work, repair, and renew the equipment, and to be paid partly in debentures and partly by annual instalments out of the earnings of the Company. A resolution was passed, with only one dissentient, authorising the Company to raise the balance (between £15,000 and £16,000) of a sum of £50,000 authorised some time ago. It was stated that a saving of about 3d. per mile would be effected in the working expenses.

Telephone Trunk Wire Extension.—The National Telephone Company has just completed an additional trunk wire between Perth and Dundee, to provide for the increased traffic between the former city and the towns connected by the Company's system. The new wire is specially intended to facilitate through communication between Perth, Glasgow, Edinburgh, and the South. The traffic from Aberdeen, Dundee, and towns in the division north of the Forth to Glasgow, Edinburgh, and the South has grown to such an extent that the Company recently decided to run additional trunk wires from Dundee to Glasgow and Edinburgh respectively, and these are now in course of erection. Of late several new trunk wires have been erected in Fifeshire to meet growing requirements there, and others are now in progress. Additional trunk communication between Dundee and Arbroath is about to be provided, and branch exchanges are proposed to be formed at Carnoustie and Brechin

Electric Lighting Shares.—A considerable amount of speculative activity, says the *Economist*, has recently been developed in electric lighting shares, due in part to the operations which are proceeding in the metropolis, and in part to the fact that the local authorities have, as a rule, shown little disposition to avail themselves of the powers conferred upon them by the Act of Parliament. It is difficult to see how the latter circumstances are to benefit the existing companies, unless it be that they are about to extend their spheres of operation. In the following table we give the quotations on Thursday of a few of the better known shares, contrasted with the prices at the end of August :—

	Price Sept. 17.	Price end of August.
Brush ordinary	2⅝	2½
Do. preference	2	1⅞
St. James's and Pall Mall ordinary	8	7
Do. preference	4⅞	4½
Swan	5⅝	4¾
Westminster	6	5½

The City Lighting.—At the meeting of the City Commission of Sewers on Tuesday, Mr. Baylis, the solicitor, reported that the chairman and he had satisfied themselves as to the position of the City of London Electric Lighting Company, to whom certain contracts for the electric lighting of the City were proposed to be transferred from other companies, and they recommended that authority for such transfer should be given, and the Board of Trade informed accordingly. This was agreed to. Mr. A. A. Wood hoped that the leading thoroughfares would not be closed by the electric lighting works during the busiest part of the autumn season. It was promised that this should be borne in mind. Mr. Ross, the assistant engineer, said the reason why the lighting of gas had been continued in streets where the electric light had been established was that certain risks and responsibilities had not been taken over by the electric lighting companies until a day or two since, but that in future in the streets in question, gas would no longer be used.

The Copper Supplies of the World.—Statistics just compiled show that in 1887 the total copper supplies of the world were estimated at 223,078 tons; in the following year they reached 258,026 tons; and in 1889, notwithstanding the depression which followed the collapse in copper speculation, the production of the metal further increased to 261,650 tons. In 1890 there was a still further jump to 269,685 tons. The most striking expansion has been witnessed in the United States, where the production rose from 25,010 tons in 1880 to 116,325 tons in 1890. During the same period the production of copper in Japan increased from 3,900 tons to 15,000 tons, and that of Spain and Portugal from 36,313 tons in 1880 to 52,335 tons in 1890. The Peninsula reached high water in copper production in 1888, when there was an aggregate of 56,450 tons. In Chili the production has greatly diminished. In 1880 the production of copper in that country reached a total of 42,916 tons, whereas last year it amounted to only 26,120 tons. With regard to the average prices realised for fine copper, in 1880 it was £63. 1s. 3d. per ton, in 1885 it had fallen to only £44. 1s. 6d., while in the following year it fell to the lowest point reached of recent years, viz., £40. 6s. In 1888 it sprang up to £76, and in 1890 it fetched £54. 1s. per ton.

Evening Classes at Finsbury Technical College.—We have been requested to mention that a new regulation has been adopted for admission to the evening laboratory classes at the Finsbury Technical College, in consequence of the overcrowding of applicants in past sessions. All applicants for laboratory work must previously fill up a form stating (*a*) the firm with whom they are employed, (*b*) the nature of their previous instruction in electricity, it being intended to reserve the laboratory places for those who are actually in the electrical industry, and for those who have previously mastered the elements of the science in one of the local science classes or Polytechnics. With the end of September the Finsbury lectures re-open. Prof. Perry will repeat on Tuesday evenings his course on the application of the differential and integral calculus to problems in mechanical and electrical engineering. Prof. Thompson will give a short course on telephones on Thursdays, commencing October 13th. On Mondays, beginning September 28th, he will occupy the advanced class with the subjects of motors and alternate-current work. On Wednesdays he will lecture on magnetism, electro-magnets, and measuring instruments. It is proposed later to have short courses of special lectures on electric locomotion and on the treatment of vector problems in the theory of electricity.

The Lake System of Electrical Conduits.—One of the first towns in the United States in which the running of wires underground was made compulsory was Washington, D.C. After protracted trials of various types of conduit, the United States Electric Lighting Company of that place finally settled upon the Lake underground system, a considerable amount of which, says the *Electrical Engineer* of New York, is now in operation and has proved eminently satisfactory. The conduit is composed of ducts built up in two tiers of terra cotta in the shape of double troughs, the bottom of the upper forming the top of the lower. These ducts are covered above and below by a cover. This is set in a bed of concrete, which also completely surrounds the ducts and keeps them firmly in position' The joints between the consecutive lengths are effected by bracket-shaped pieces, which clasp the conduits and which are held firmly in position by the concrete as it is rammed about them. This form of conduit has not only been used in electric lighting, but is now being introduced in Washington for telephone lines. The United States Electric Lighting Company, in Washington, has 30 to 35 miles of it with a cable capacity of over 500 miles. The Chesapeake and Potomac Telephone Company are now completing five miles with a cable capacity of at least 250 miles, and the same telephone company laid ten miles last year in Baltimore. The system is also coming into use in Chicago, St. Paul, Minneapolis, Cleveland, Louisville, San Francisco and Milwaukee.

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ELECTROMAGNETIC THEORY.—XVI.

BY OLIVER HEAVISIDE.

(*Continued from page 495.*)

§ 86. From the last formula we see that to have moving force in a non-conductor (free from electrification, &c.) requires not merely the coexistence of electric and magnetic force, but also that one or other of them, or both, should be varying with the time. That is, when the energy flux is steady, there is no moving force, but when it varies, its vector time variation, divided by v^2, expresses the moving force.

The direction of **W** is a natural one to choose as one of the axes of reference of the stress, being perpendicular to both **E** and **H**, which indicate the axes of symmetry of the electric and magnetic stresses. The two lateral pressures combine together to produce a stress on the **W** plane

$$\mathbf{P}_{W1} = -\mathbf{W}_1(U+T), \quad . \quad . \quad . \quad . \quad (31)$$

where $\mathbf{W}_1$ is a unit vector parallel to **W**. (Take $\mathbf{N} = \mathbf{W}_1$ in the general formula (30) § 72 for $\mathbf{P}_N$).

If, further, **E** and **H** are perpendicular to one another, the stresses on the planes perpendicular to them are

$$\mathbf{P}_{E1} = \mathbf{E}_1(U-T), \quad . \quad . \quad . \quad . \quad . \quad (32)$$

$$\mathbf{P}_{H1} = \mathbf{H}_1(T-U), \quad . \quad . \quad . \quad . \quad . \quad (33)$$

which are also entirely normal. Here $\mathbf{E}_1$ and $\mathbf{H}_1$ are unit vectors. Thus, $\mathbf{W}_1$ is always a principal stress axis, while $\mathbf{E}_1$ and $\mathbf{H}_1$ become the other pair of principal axes when they are perpendicular, as in various cases of electromagnetic waves.

Thus when a long straight wire supports a steady current, or else is transmitting waves, the principal axes of the stress at a point near the wire are respectively parallel to it and perpendicular to it, radially and circularly. The first one has a pressure $(U+T)$ acting along it, the second (parallel to **E**) a pressure $(T-U)$, and the third (parallel to **H**) a pressure $(U-T)$. (This legitimate use of pressure must not be confounded with the utterly vicious misuse of pressure to indicate E.M.F. or voltage, by men who are old enough to know better, and do.) In general, U and T are unequal. But in the case of a solitary wave or train of waves with negligible distortion U and T are equal, and there is but one principal stress, viz., that with axis parallel to **W**, a pressure 2U or 2T. It is this pressure (or its mean value) that is referred to as the pressure exerted by solar radiation, and its space variation constitutes the moving force before mentioned. This matter is still in a somewhat speculative stage.

It is natural to ask what part do the stresses play in the propagation of disturbances? The stresses and accompanying strains in an elastic body are materially concerned in the transmission of motion through them, and it might be thought that it would be the same here. But it does not *appear* to be so from the electromagnetic equations and their dynamical consequences—that is to say, we represent the propagation of disturbances by particular relations between the space and the time variations of **E** and **H**; and the electromagnetic stress and possible bodily motions *seem* to be accompaniments rather than the main theme.

§ 87. In § 83 it was remarked that the flux induction due to an intrinsic magnetic forcive depends not upon itself directly, but upon its curl, and in § 84 a similar property was pointed out connecting the flux displacement and intrinsic electric force. That is to say, the fluxes depend upon the vectors $\mathbf{j}_0$ and $\mathbf{g}_0$, not upon $\mathbf{e}_0$ and $\mathbf{h}_0$. This remarkable and, at first sight, strange property, which is general, admits of being demonstrated in a manner which shall make its truth evident in a wider sense, and lead to a connected property of considerable importance in the theory of electromagnetic waves.

Let there be any impressed forcive $\mathbf{e}_0$ in a stationary medium. Its activity is $\mathbf{e}_0\mathbf{J}$ per unit volume, where **J** is the electric current, and the total activity is $\Sigma\mathbf{e}_0\mathbf{J}$, where the Σ indicates summation through all space, or at any rate so far as to include every place where $\mathbf{e}_0$ exists. Its equivalent is Q_0, the total rate of waste of energy, and the rate of increase of the total stored energies, say U_0 and T_0. Thus,

$$\Sigma\mathbf{e}_0\mathbf{J} = Q_0 + \dot{U}_0 + \dot{T}_0 \quad . \quad . \quad . \quad . \quad . \quad (34).$$

Now, the value of the summation is zero if $\mathbf{e}_0$ has no curl, or is irrotational—that is, an irrotational forcive does no work upon a circuital flux. This proposition may be rendered evident by employing a particular method of effecting the space summation, viz., instead of the Cartesian method of cubic subdivision of space, or any method employing co-ordinates, divide space into the elementary circuits belonging to the flux. (Here it is J.) Fixing the attention upon any one of these circuits, in which the flux is a constant quantity, we see at once that the part of the summation belonging to it is the product of the impressed voltage in the circuit and the flux therein. But there is no impressed voltage, because $\mathbf{e}_0$ has no curl; hence the circuit contributes nothing to the summation. Further, since this is true for every one of the elementary circuits, and inclusion of them all includes all space, we see that the summation $\Sigma\mathbf{e}_0\mathbf{J}$ necessarily vanishes under the circumstance stated of $\mathbf{e}_0$ being irrotational.

Now return to equation (34), and suppose that the initial state of things is absence of **E** and **H** everywhere, so that Q_0, U_0 and T_0 are all zero. Next start any irrotational $\mathbf{e}_0$, and see what will happen. The left side of (34) being zero, the right side must also be and continue zero. But Q_0, U_0 and T_0 when not zero are essentially positive. Now if (U_0+T_0) becomes positive, Q_0 should become negative, in order to keep the right number of (34) at zero. This negativity of Q_0 being impossible, these quantities Q_0, U_0 and T_0 must all remain zero. Consequently **E** and **H** must remain zero. That is, an irrotational forcive can produce no fluxes at all, if the flux corresponding to the force is restricted to be circuital.

It should be observed that this proposition applies not merely to the steady distribution appropriate to the given forcive, but to all intermediate stages, involving both electric and magnetic force, and flux of energy. Nothing happens, in fact, when any distribution of impressed force is made to vary in time and in space, provided it be restricted to be of the irrotational type, so that the voltage (or the gaussage) in every circuit is nil.

Notice further the dependence of the property upon circuitality of the factor with which the impressed force is associated (thus **J** with $\mathbf{e}_0$, and similarly **G** with $\mathbf{h}_0$), and the positivity of energy; and, more strikingly, the independence of such details as are not concerned in equation (34), such as the distribution of conductivity, permittivity, &c., or of the forces being linear functions of the fluxes.

§ 88. Returning to (34) again, we see that any two impressed forcives produce the same results in every particular, as regards

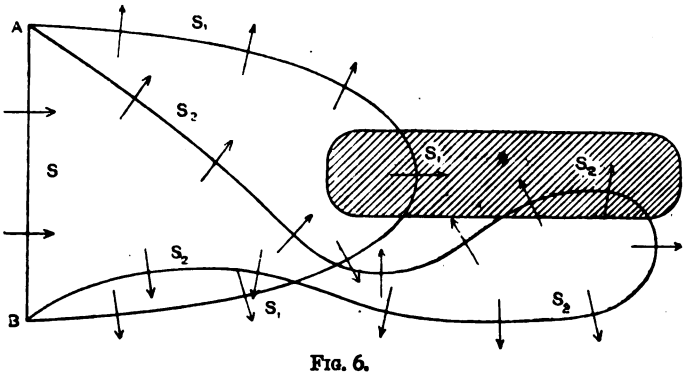

FIG. 6.

the varying states of **E** and **H** gone through, if their curl is the same. For the difference of the two forcives is an irrotational forcive, and is inoperative. Here it is desirable to take an explicit example for illustration of the meaning and effect. Describe a linear circuit in space, and a surface bounded by the circuit (Fig 6). Over this surface, which call S, let an impressed force V act normally, V being the same all over the surface. This system of force is irrotational everywhere except at the bounding circuit, where there is a circuital distribution of $\mathbf{g}^0$ the curl of $\mathbf{e}_0$, of strength V.

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Now, our present proposition asserts that the disturbances due to V over the surface S are in every respect the same as those due to V (the same normal impressed force), spread over any other surface bounded by the same circuit. The comprehensiveness of this property may be illustrated by supposing that one surface is wholly in a non-conductor, whilst the other passes through a conductor; or that one surface is wholly within a conductor, whilst the other passes out of it and through another conductor insulated from the first. Thus, in the diagram, let S be the first surface (in section), and S_1 the second, passing through a conductor represented by the shaded region. The points A, B are where the common boundary of the two surfaces cuts the paper, whilst the arrows serve to show the direction of action of the impressed force. S_2 is another surface of impressed force, also reaching into the conductor. Now all these forcives (each by itself) will produce the same final state of displacement in the dielectric and electrification of the conductor, and will do so in the same manner; that is, the electromagnetic disturbances generated will be the same when expressed in terms of **E** and **H**. The distribution of energy, for example, and the stresses, will be the same.

But there must be some difference made by thus shifting the source of energy. Obviously the nature of the flux of energy is changed. This being

$$\mathbf{W} = \mathrm{V}(\mathbf{E} - \mathbf{e}_0)(\mathbf{H} - \mathbf{h}_0),$$

where we deduct the intrinsic forces to obtain the forces effective in transferring energy, we see that every change made in the distribution of the intrinsic sources affects the flux of energy, in spite of the independence of **E** and **H** of their distributions (subject to the limitation mentioned). In our example, however, the only change is in the sheet of impressed force itself.

§ 89. It may be readily suspected from the preceding, that, as far as the production of electromagnetic disturbances goes,

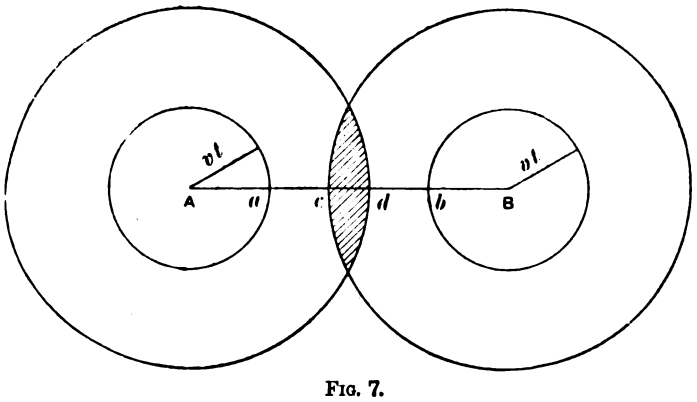

Fig. 7.

we may ignore $\mathbf{e}_0$ and $\mathbf{h}_0$ altogether, and regard the circuital vectors $\mathbf{g}_0$ and $\mathbf{j}_0$ as the real sources. This is, in fact, the case when ultimately analysed. In the example just taken the circuit ABA is the source of the disturbances. That is, they emanate from this line. If disturbances were propagated infinitely rapidly there might be some difficulty in recognising the property, because the steady state appropriate to the instantaneous state of the impressed force would exist (if the conductor were away); but, as we shall see later, the speed of propagation is always finite, depending upon the values of c and μ in the medium; and conduction does not alter this property, although by its attenuating and distorting effects it may profoundly alter the nature of the resultant phenomena. With, then, a finite speed of propagation, we have merely to cause the impressed force to vary or fluctuate sufficiently rapidly to obtain distinct evidence of the emanation of waves from the real sources of disturbance. Thus, let the source be circular in a plane perpendicular to the paper (Fig. 7), and A, B the points where it cuts the paper. When the source is suddenly started, the circle ABA is the first line of magnetic force. At any time t later, such that vt is less than the distance $\frac{1}{2}$AB, the electromagnetic disturbance will be confined wholly within a ring-shaped region having the circular source for core and of radius vt round A or round B. But when the distance vt increases to $\frac{1}{2}$AB overlapping commences, and a little later there is (as in the shaded part of the figure) a region occupied by two coincident waves crossing one another. Now, the union of these waves produces the steady state of displacement without magnetic force—that is, within the shaded region the magnetic force vanishes, and the displacement is that which belongs to the final steady state. As time goes on, of course the shaded region enlarges itself indefinitely, although outside it is still a region occupied by electromagnetic disturbances going out to infinity. This supposes that there is no conductor in the way. Should there be one, then, as soon as it is struck by the initial electromagnetic wave, it becomes and continues to be a secondary source of disturbance, and the final steady state, different from the former, now arises from the superimposition of the primary waves and the secondary.

It is, of course, impossible to go into detail at present, the object being merely to point out the difference between sources of energy and sources of disturbance. The source of energy only works when there is electric current at the spot, and this comes to it from the vortex lines (the circuital sources of disturbance). Thus, in the last figure, at time vt, when the ring of disturbance is of thickness $2vt$, if the impressed force be in a circular disc whose trace is the straight line AB, the force is working in Aa and in Bb, but inoperative elsewhere. Again, after overlapping has begun it is still working in Aac and Bbd, but is inoperative in cd, having done its work. Similarly when the sheet of impressed force has any other shape. The impressed force only works when it is allowed to work by the electromagnetic wave reaching it.

To emphasize the matter, take another case. Let the impressed force in any telegraph circuit be confined to a single plane section across the conductor, so that the vortex line is a line on its surface, going round it. If this be at Valencia, we may shift the "seat of the E.M.F." to Newfoundland, provided we preserve continuity of connexion with the vortex line, as before explained; for instance, by extending the sheet over the whole surface of the conductor between the two places. The sheet at Newfoundland and the surface sheet will together produce the same effects as the original sheet at Valencia. Or, we may have the sheet entirely outside the circuit, provided only that it is bounded by the original vortex line, in touch with the conductor.

What the practical interpretation of this extraordinary property is in connection with the "seat of E.M.F." of galvanic batteries and in electrolysis generally still remains obscure. All impressed voltages and gaussages are more or less difficult to understand. But there need be no doubt as to the general truth of the property if the circuitality of the current can be trusted.

(To be continued.)

THE DETERMINATION OF CURRENTS IN ABSOLUTE ELECTRO-MAGNETIC MEASURE.

BY G. F. C. SEARLE, M.A.

(Continued from page 555).

§ 14. **Equipotential Surfaces.**—An equipotential surface is one at all points of which the potential is the same. From this definition we see that no work is done in taking a unit pole from any one point on the surface to any other point on the surface. Taking two points, A B, close together on the surface, we see that since no work is spent upon the pole in moving it from A to B, the lines of force near A B must be perpendicular to the surface there, otherwise there would be a component force along A B, and work would have to be done. To draw the equipotential surfaces on the proper scale, they must be so drawn that, in going from one surface to the next, one erg of work is expended on the unit pole. If we do this then this set of surfaces may be used instead of the lines of force to indicate the state of the magnetic field at every point of space.

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For if n (Fig. 14) is the normal to any equipotential surface at any point P, the force along n in the direction in which n increases is $-\frac{dV}{dn}$, and this is the resultant force experienced by the pole since the resultant force is perpendicular to the equipotential surface. Thus, if H is the resultant magnetic force at any point of the field, $\mathsf{H} = -\frac{dV}{dn}$. Now, taking $dV = 1$, which corresponds to a passage from one equipotential surface to the next, the surfaces being drawn in the manner just indicated, we have $\mathsf{H} = -\frac{1}{dn}$ where dn is the distance in centimetres from one equipotential surface to the next, measured along the normal. We now see how the set of equipotential surfaces maps out the field, for the normal to any surface at any point on it, gives the direction of the magnetic force, while unity divided by the distance, measured along the normal from

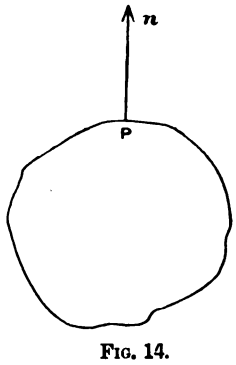

FIG. 14.

one surface to the next, is equal to the magnetic force. The curves in which the equipotential surfaces due to a magnet are cut by any plane can be found experimentally in the following way :—Place a magnet on a drawing-board covered with paper. Take a small compass, which has attached to its magnet a small brass cross-piece at right angles to the axis of the magnet. Place the compass on the board and make marks exactly opposite each end of the cross piece. Let A B be its two ends. Move the compass and place it so that the end A occupies the old position of B. By repeating this operation we shall obtain a set of points, and the curve drawn through them all will be a close approximation to the curve required. The same operation performed with the compass magnet itself instead of with its cross piece will plot out the lines of magnetic force. The paper will be divided up into small quadrilaterals, whose angles are right angles and whose sides are very slightly curved. Diagrams of this description will be found at the end of Maxwell, Vol. II.

§ 15. The system of tubes of induction, and of equipotential surfaces, divides up the whole field into a large number of cells.

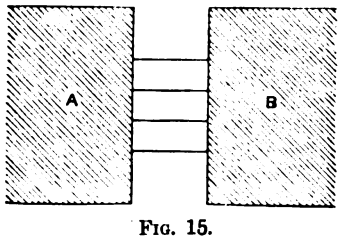

FIG. 15.

Let us inquire as to the size of these cells at a place where the magnetic force is H. We have seen that at such a place the cross section of a tube of induction is $\frac{1}{\mathsf{H}}$ square centimetres, while the distance from one equipotential surface to the next is $\frac{1}{\mathsf{H}}$ centimetres. Accordingly, the volume of each cell is $\frac{1}{\mathsf{H}^2}$ cubic centimetres, or there are H^2 cells per cubic centimetre of the field. These cells have a very deep significance on Maxwell's Theory. We will look a little more closely into the matter. Suppose we have two magnets, A B (Fig. 15), with large flat ends, uniformly magnetised. Let the ends A and B be placed very close together and parallel, A being a north pole and B a south one. Let H be the magnetic force at any point between A and B; this will be perpendicular to both of the faces and in the direction A to B. Then there are H tubes of induction proceeding from each square centimetre of the pole A, and ending on the pole B. If σ is the strength of the pole A per square centimetre, then since 4π tubes proceed from every unit pole, the value of σ must be $\sigma = \frac{\mathsf{H}}{4\pi}$ Now, a unit pole placed between the faces is acted on by a force H dynes from A towards B. But since the ends are very large indeed, compared with the distance between them, the force on the unit pole due to each end will be independent of the distance (always very small) of the pole from the end. Hence we see that each end produces by itself a magnetic force $\frac{1}{2}\mathsf{H}$. Now consider the magnetism on the face B. There are $\frac{\mathsf{H}}{4\pi}$ units of south magnetism per square centimetre. This is acted on by a magnetic field whose strength is $\frac{1}{2}\mathsf{H}$, due to the opposite pole. Thus each square centimetre of the face B is attracted to the face A with a force $\frac{\mathsf{H}^2}{8\pi}$ dynes. Now separate the two poles slightly further by a distance x. The work done is $\frac{\mathsf{H}^2}{8\pi}x$ ergs per square centimetre of face. By the movement we have increased the volume between the poles by x cubic cm. per square cm. of face. Each cubic cm. contains H^2 cells, so that the number of cells in the field has been increased by $\mathsf{H}^2 x$ per square cm. of face. Comparing the work done and the number of cells formed, we see that the formation of one cell has involved the expenditure of $\frac{1}{8\pi}$ ergs of work. Maxwell supposes that the energy of all electrical and magnetic systems is really distributed throughout the field. We may accordingly suppose that each cell contains $\frac{1}{8\pi}$ ergs of energy. The above demonstration is hardly exact unless the size of the ends of A and B is infinite compared with the distance between them, but it seems to put the matter in a fairly clear light. Although we cannot assert definitely that each *cell* does contain $\frac{1}{8\pi}$ ergs of energy, yet we can show by a more elaborate process that we are always able to assert that the whole potential energy of the magnetic system is equal to the whole number of cells in the field divided by 8π.

§ 16. The attraction of the two ends A and B is brought about, according to Maxwell, by a stress in the medium between the poles. There must be a tension $\frac{\mathsf{H}^2}{8\pi}$ dynes per square centimetre in the direction of the magnetic force, since this is the force per square cm. which either face experiences. The energy per cubic cm. is also $\frac{\mathsf{H}^2}{8\pi}$ ergs, since there are H^2 cells per cubic cm., so that the tension per square cm. and the energy per cubic cm. are equal. It is very instructive to compare the case we have been considering with that of a soap film. Suppose we have a wire framework, A C D (Fig. 16), the side A being l centimetres long, and a bar, B, sliding on the sides C D. Let a soap film be placed on the space A B. It will endeavour to pull the bar B towards A. Let B be pulled further from A through a distance x. Let T be the surface tension, *i.e.*, the pull across each centimetre of the surface. The force exerted on B by the film is then Tl dynes, and the work we do in displacing B through x centimetres is Tlx ergs. But lx square cm. is the increase in the surface of the film, so that we have done T ergs per each square centimetre increase of the film, and we are, in consequence, led to suppose that the soap film contains T ergs of energy per square centimetre of surface.

Maxwell (Vol II., ch. XI.) has shewn that if in addition to the tension $\frac{\mathsf{H}^2}{8\pi}$ along the lines of force there is a pressure in

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the medium at right angles to the lines of force equal to $\frac{H^2}{8\pi}$ dynes per square cm., then all the forces experienced by magnets and currents can be accounted for. We have here merely put into a quantitative form the conception of Faraday that the lines of magnetic force tend to shorten themselves, and that they repel each other when placed side by side. When the medium with which we are dealing can become magnetised the expressions for the stresses become rather more complicated. For this case we must refer the reader to Maxwell.

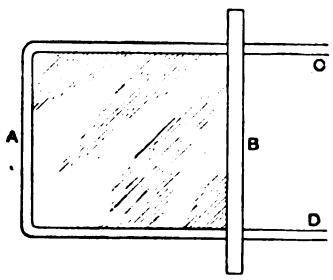

Fig. 16.

§ 17. We will now find the magnetic potential due to a single pole of strength m placed at O (Fig. 17). The force experienced by the unit pole at P is $\frac{m}{OP^2}$. If we supposed that this remains constant while we move the unit pole from P to a very near point Q, then the work spent upon the pole would be $\frac{m}{OP^2}(OP-OQ)$. If we supposed the force remains the same as it is at Q, the work would be $\frac{m}{OQ^2}(OP-OQ)$. The first expression is larger and the second smaller than the true amount. But we get a very close approximation by putting for the work done the expression $\frac{m}{OP\cdot OQ}(OP-OQ)$. But this is equal to $V_Q - V_P$. Hence

$$V_Q - V_P = \frac{m}{OP\cdot OQ}(OP-OQ) = \frac{m}{OQ} - \frac{m}{OP}.$$

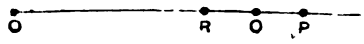

Fig. 17.

Going from Q to the near point R, we have in the same way $V_R - V_Q = \frac{m}{OR} - \frac{m}{OQ}$, and, therefore, by addition, $V_R - V_P = \frac{m}{OR} - \frac{m}{OP}$. By proceeding in this way we see that if A and B are any two points $V_A - V_B = \frac{m}{OA} - \frac{m}{OB}$. Now we consider the magnetic potential at infinitely distant points to be zero. Take then B to be infinitely distant, then $V_B = 0$ and $\frac{m}{OB} = 0$, and we thus find $V_A = \frac{m}{OA}$, or simply $V = \frac{m}{r}$ when r is the distance of the point at which we require the potential from the pole. In other words, the work spent upon a unit magnetic pole in bringing it from an infinite distance to within a distance r from a pole of strength m is $\frac{m}{r}$ ergs. This is the potential energy of the system of the two poles. If we had brought up a pole of strength m' the potential energy of the system would have been $\frac{mm'}{r}$ ergs.

Erratum.—In the issue for September 11th the last formula of § 6 should read $T = 2\pi\sqrt{\frac{K}{MH}}$, *instead* of $T = 2\pi\sqrt{\frac{MH}{K}}$.

(To be continued.)

THE VELOCITY OF LIGHT REGARDED AS A VELOCITY OF MATTER.

BY S. TOLVER PRESTON.

If we accept the conclusion as axiomatic that matter alone can possess velocity, still some may find a difficulty in conceiving, even in its most ultimate form, the objective existence of a velocity equal to that of light.

But if there be no "Force" (spiritual) in the domain of Physics—"action at a distance" (assumed *instantaneous*) being supposed rejected—then surely something must move at not less* than the velocity at which light is propagated. It may be all very well to say light is propagated in the form of a wave. But what is the mechanism which propagates the wave, if there be no (spiritual) "Force?" Something material must get across space at the speed of a wave of light. We cannot traverse space without matter by the aid of a wave.

In a somewhat parallel way in principle, at least (without knowing whether light is carried forward in a succession† of curved or straight lines), if the molecules of *air* exert no "Force" or distant influence on each other, these molecules can obviously have no means of acting on each other, excepting by direct impact, and, therefore, they must possess normally a velocity not less than that of the wave which they propagate—a wave of sound in this case.

If, then, the reality of the existence of a velocity of matter not less than that of light can be inferred, the question may be how to facilitate the conception of it. The fact may be cited that it has been demonstrated mathematically that according to the modern kinetic theory of gases, the velocities of the molecules of the atmosphere (in continual interchange of motion among themselves), vary within an *indefinitely* great range. We cannot imagine an infinite velocity; but the theorem that the velocities of the molecule of a gas "vary between zero and infinity," must at least imply that there is no assignable limit to the velocities attainable by molecules in the accidents of their encounters, provided the number of molecules be not limited. The number of molecules in the atmosphere is great enough to allow enormous velocities at times according to the above mathematical theorem, which would entail, perhaps, speeds in excess of that of light, now and then.

But I have pointed out (*Phil. Mag.*, May, 1891, p. 441, "Some Remarks on the Kinetic Theory of Gases") that the friction in the ether and other causes would tend essentially to curtail the speed which molecules might otherwise accidentally acquire. But if a molecule of air can (in the contingencies of its encounter with others) perhaps attain a speed equal to that of light occasionally, though rarely, and certainly would exceed this speed sometimes but for the friction in the ether, how simple is it to conceive what must be very much smaller portions or particles of matter in the form of ether, possessing normally a velocity not less than that of light. For such particles of ether have nothing comparable to the friction of passage to surmount, which the relatively big molecules of the atmosphere have, moving in ether. We have spoken of "particles" of ether, which, of course, involves the assumption that the ether is of some sort of *molecular* constitution. The idea of a *non*-molecular ether can‡ scarcely be called a conception, and has gained no real ground.

As regards visible velocities capable of being acquired by matter, we may observe that even the relatively gross masses constituting comets are seen to traverse the ether at speeds of 300 miles per second or more. So that to imagine particles of matter moving without friction, and so minute as those constituting the ether must be, to possess normally the speed of

* This is, perhaps, only approximately true (?) in the case of a fluid theory of matter into the consequences of which I do not presume to enter; but in any case this Paper may awaken thought and be useful to publish, especially on account of the practical interest now attached to the ether.

† It is not implied, of course, that light is propagated like sound; all that is contended is that a velocity cannot get across space without matter accompanying the velocity—no consequence what direction the velocity takes or how it varies.

‡ We have elsewhere laid stress on the fact that, according to the vortex atom theory, the ether would be necessarily atomic or molecular; but it is doubtless best to be independent of particular theories of the nature of matter generally.

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light, is easy enough. The remarks apply practically to the tentative calculations (as rough limiting values) for stored-up energy, pressure, &c., illustratively offered in a former article, "On the Energy capable of being Stored in the Matter of Space or Ether," in *The Electrician* of June 12th, when this natural velocity unit was taken, not merely as a vague conception, but as representing a velocity of matter, from which we may derive approximate estimates of the energy silently stored in the material body, concealing this velocity within itself.

It must surely, after all, be an axiom that "velocity" can only be applied to matter, for "force" is assumed (not conceived) to be *instantaneously* propagated; so that it appears questionable if we can apply the term "velocity" here. Even if this assumption of "action at a distance" be encouraged as a speculative possible truth (although admittedly inconceivable), yet this, obviously, should not hamper independent inquiry. If, on the other hand, "action at a distance" be dismissed from the thoughts entirely, then the mere admission that a velocity of matter, not less than that of light exists, must deductively have vast consequences in regard to the ether, which then presents itself to us as the prime source of motion and storehouse of energy.

ELECTRIC LIGHT IN HOLLAND.

In a country where so curious a mixture of imperturbability and enterprise, of thrift and luxury, is to be found, it seems to be a mere chance whether electric light will spread rapidly or struggle ineffectually. It happens that what little electrical work there is has been put down by Germans, and though it is spreading on its own merits, it is not likely to be taken up so well as if some Dutch engineers could be found to turn their attention from canal cutting and dyke building. Numerous factories are provided with their own electric light plants here, as all over the world; but, as far as we are aware, there are only two public supply stations, the one at the busy capital, Amsterdam, and the other at the fashionable residence of the Court at the Hague.

On a recent occasion we took the opportunity of visiting these two stations, tracking them down in each case by the chimney shafts and their exhalations; for the Dutchman is justly proud of the picturesqueness of his streets, and allows no overhead wires. With praiseworthy impartiality, Holland has adopted alternate currents in one station and low-pressure with batteries at the other, and as far as the light is concerned, both glow lamps and arcs are thoroughly first class, the former being well up to colour, the latter steady and silent, both giving general satisfaction and not known to fail.

At the Hague we found the *Centraal Station voor Electrische Stroom levering*, a substantial building consisting of a commodious engine-room and "kettle-house," surrounded by and overlooked by a glazed corridor communicating with the various offices of the supply company. The whole of the plant, from the dynamo to the lamps themselves, including the mains, is supplied by and is the design of Messrs. Siemens and Halske, who are represented by the chief engineer, Mr. N. J. Singels. A pair of horizontal engines had been at work, but are now dismantled, and are being moved to allow for extension of the plant, on account of the increasing demand for light. The three-wire low-pressure system with batteries is employed, and the load last month was equivalent to rather more than 3,000 16-candle lamps. The engines are of an inverted marine type, and drive two dynamos, one at either end of the shaft, the driving of course being direct. There are two of these sets, and there is plenty of room for two or three more. We do not like to criticise the dynamos, the fact that more of them are being built is some proof that they are satisfactory, even if the eulogistic account which was given to us is put down to enthusiasm and pride in the work of so well-known a firm. They are of the inside-pole, outside-commutator pattern, as described and illustrated in our issue of August 28, p. 461. The stationary magnets are like those of the Jablochkoff dynamo; and the armature wound Gramme-ring fashion, with bar conductors, is overhung. The outer surface of the armature acts as a commutator; and although the machine appears to be very expensive to build, it must be admitted that the trouble of attaching the sections of a separate commutator is thus avoided. It was pointed out to us that the centrifugal force in such an armature is balanced by the pull of the field-magnets; but the only advantage that we can see in this type of machine is the reduction of angular speed of the armature and shaft, at the cost of considerable mechanical stress and very large peripheral speed of commutator. It is rather remarkable that while the English firm of Siemens Bros. have put down a set of dynamos at the Naval Exhibition of the largest and most substantial character, and of a design and workmanship that cannot fail to please the eye of an English engineer, their German allies should deliberately build such strange machines. There is no reason why the efficiency should not be excellent, and the only points about which we are inclined to be sceptical are the cost and the durability.

Only a small battery capacity is provided at the Hague station, and it is employed in much the same way as at Kensington and Knightsbridge. An all-day supply is provided, all the private houses and smaller customers being charged by meter, while the hotels and large establishments are charged by contract. A large switchboard, placed in a gallery overlooking the engine-room, controls the various feeders and mains, voltmeters with pilot wires from the ends of the feeders and ammeters being provided, while an attendant controls the pressure by means of resistances. In the *ketel-huis* large locomotive boilers are used, and, the remaining space being limited, a water-tube boiler is being put down. The economy of this station appears to be remarkable, but the figures which we saw cannot be compared directly with those of our London stations, though we hope that the Chamber of Commerce scheme of gathering statistics will enable a just comparison, in such a case as this, to be made. Load diagrams are taken every day, and among the various analyses which are made is one which gives the "ampere-hours per kilogramme" of coal. This appears to vary from 2·8 to 3. There being, say, 110 volts, this gives 308 to 330 watts for 2·2lb., or 5·33 to 4·97lb. per E.H.P. Siemens' armoured cable is used, many of the feeders being concentric conductors.

At Amsterdam a beginning was made in the centre of a large block of houses in the busiest part of the city, and overhead wires were run to various shops and hotels. The light being appreciated, more plant was put down, and permission was granted for running underground conductors. Alternating currents are used, one dynamo running direct on the mains, and the other on alternators. The high-pressure service is at 2,000 volts, and is transformed to 72 volts for the glow lamps and to 36 volts for the arcs. The dynamos are of Ganz's make, and resemble the Siemens' continuous-current dynamos at the Hague, in having overhung ring-armatures with fixed internal magnets, and are direct driven by horizontal engines. The space in the engine-room is very limited, and the supply company hope to remove shortly to larger premises. The underground conductors are made by Felten and Guilleaume, the larger ones being concentric; they are lead covered, and are laid in wooden troughs, filled in with asphalte and covered with stone flags. The supply is not maintained all day, but the whole of it is charged by meter, considerable abatement being made to large consumers. Frager and Aron meters are used, and a meter of Messrs. Ganz and Co. made by the Helios Company. The transformers, arc lamps, and many of the accessories are of Ganz's design, but manufactured by the Helios Company.

The price charged at Amsterdam is 8d. (40 cents) per 1,000 watt hours; and lamps are to be bought, having a life of 1,000 hours, and an efficiency of 3½ watts per candle, for 1s. 8d. to 2s. The price of current compares well with that which is charged in London, when it is remembered that while the gulden (100 cents) is worth 1s. 8d., it only goes as far as a shilling in most purchases; and the price of 8d. may, for practical comparison, be reduced to less than 5d. It is a pleasure to find such good results, and that the work is well and carefully carried out, with no unsightly temporary makeshifts. On a future occasion we hope to describe an equally satisfactory specimen of accumulator traction in Holland.

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GAS-ENGINE SUB-STATIONS.

The proposal which has been made by the Gas Company of Cork to generate and supply electrical energy by means of scattered stations worked by gas engines, offers a very interesting problem to the engineer, and is a matter of considerable importance to many others than the inhabitants of the town in question. Taking the price of electric supply on the one hand at 7d., or even the 6d. which is talked about but not frequently found in practice, and reckoning the cost of generating a unit by gas engines at less than 2d., there is something very tempting in the idea. It is obvious that this scheme not only makes use of the existing gas mains instead of expensive conductors, but does away with the necessity for a special staff of clerks and collectors, to say nothing of directors. We have alluded more than once to the subject in these columns, and have commented on the policy and the cost of such a scheme, our attention having recently been called to it by the leading gas journal. On the latter occasion it was proposed to use this system in Glasgow, and there it would have had a more satisfactory field than at Cork; but it would be interesting to see the system tried on a fair scale, and our gas friends must excuse us if we venture to prefer that the cost of such an undertaking should fall upon them. For the electrical industry has sunk too much money in pioneer work which has turned out to be more useful as a lesson than profitable as an investment.

There are a good many different points requiring careful consideration; for while the principle of feeding a low-pressure network by separate dynamos avoids the use of mains and feeders, the generating stations cannot be multiplied without serious increase of capital expenditure and cost of labour. We may take for an example a station capable of running 500 16-candle lamps, say 32 kilowatts. The slow speed of gas engines makes direct driving out of the question, and belting would have to be used; so that a commercial efficiency of more than 86 per cent. could not be expected, thus demanding 50 horse-power, or 1,250 cubic feet of gas per hour. Taking gas at 3s. per thousand, we consume 45d. worth per hour, getting

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a unit of electrical energy for 1·4d. It is this figure, so easy to calculate, which is at first so encouraging. But, after all, this only represents the consumption of fuel; and this we know, from Mr. CROMPTON'S last Paper, may be put, under favourable circumstances, at a slightly lower figure. When we say "favourable circumstances" we refer to existing stations and not to ideal ones. If it were not for the unfortunate waste in the boilers we might approach the 2½lb. of coal per unit, which ought to be sufficient, and which is amply sufficient when the plant is subjected to a regular test. This would bring down the fuel to 0·275d. per unit, and gas would have to make up the difference between this and 1·4d. in other directions if it ever has this price to compete with. It is, however, to be remembered that in the case of gas supplied by a gas company to its electrical department, the actual cost of production of the gas would probably be charged, so that the cost per electrical unit generated would be less than the 1·4d. worked out above, though how much so would depend upon the manner in which the accounts of the electrical concern were entered in the Company's books.

The cost of plant and, therefore, the upkeep, must necessarily be dearer under this system of distribution by gas engines. A reserve must be kept at almost every station; and not only do two 50 H.P. dynamos cost more than one of 100 H.P., but gas engines are very expensive machines for their output when all the tanks and fittings are included, and the cost of the several buildings must be added. The boilers of a steam station must not be taken together with the engines in making a comparison with gas engines, since the gas company practically throw in the cost of generation in the price of the gas. If it is proposed to use even a small battery reserve, the cost of labour in attending to a number of scattered accumulators would be very appreciable, and it is not easy to see how light loads could be met satisfactorily unless by using two gas engines to each dynamo. If, however, there is one member of the gas industry who is better able than another to plan and to develope such an undertaking, Mr. DENNY LANE, the secretary of the Cork Gas Company, is the man.

THE FRANKFORT CONGRESS OF 1891.

BY PROF. SILVANUS P. THOMPSON, F.R.S.

Electrical Congresses are not held with the recurrent regularity of the meetings of the British Association. That which has been held this year at Frankfort differs from its predecessors in Paris in many ways, most of all in that it did not profess to be representative of the abstract science at all, being avowedly of an electro-technical character. The absence from such a gathering of such leaders as Sir William Thomson, Prof. H. von Helmholtz, Monsieur Mascart, and Prof. Rowland, is quite sufficient in itself to mark the difference. In the proceedings of the Congress itself there were no discussions on matters of refined theoretical importance; the Congress bore a strictly matter-of-fact aspect, and confined its attention to questions of practical interest. Further, the Congress was not official in the same sense as the Paris Congress of 1881, which was got up under the direct patronage of the Government of the French Republic, and to which most of the delegates were officially designated by their respective Governments. It is true that the opening session of the Frankfort Congress was honoured by the presence of the ever popular Postmaster-General of the German empire, his Excellency Dr. von Stephan. But the delegates present were mostly chosen—so far as they had any standing at all to distinguish them from the crowd of members who became such by purchase of a ticket—by the various electro-technical societies, not by the Governments of their respective countries.

The Congress began on the evening of Monday, September 7th, in the large restaurant of the Electrical Exhibition, with a "greeting," or informal reception, the homely Teutonic heartiness of which stood out in strong contrast with the frigid ceremonial of the corresponding function at the British Association Meeting at Cardiff, from which several of the English party had gone almost direct to Frankfort.

On Tuesday, September 8th, the work of the Congress began with a general assembly in the Victoria Theatre in the Exhibition grounds. The members were welcomed by Privy Councillor Heldberg, honorary president of the Electro-technical Society of Frankfort, to the initiative of which body both the Exhibition and the Congress owe their origin. Then followed an introductory oration by his Excellency Dr. von Stephan, who announced the interest taken in electrical matters by the German Kaiser, reviewed the progress of electrical science since the Paris Congress of 1881, touched on the commercial questions relating to the development of the industry, referred to the alarming rate at which our coal supplies are being used up, expressed the hope that electricity would enable us to utilise other natural forces, deprecated undue speculation, and ended by declaring the Congress open. Then followed the election of Dr. Werner von Siemens as president, and of the five vice-presidents, Mr. Preece of London, M. Hospitalier of Paris, Prof. Ferraris of Turin, Prof. von Waltenhofen of Vienna, Prof. Carl Hering of Philadelphia, and Prof. Kohlrausch of Hanover; and as secretaries, Herr Uppenborn of Berlin, Prof. Heim of Hanover, Herr Hartmann, and Postrath Ebert of Frankfort. As secretaries of sections, Dr. Epstein, Dr. O. May, Dr. von Nordheim, and Prof. Lepsius. Some words of welcome were also spoken by the Burgomaster Adickes, in the name of the city of Frankfort, and by Herr Sonnemann in that of the Committee of the Exhibition.

Formalities having been concluded, the Congress settled down to hear a Paper by Prof. Kohlrausch on the topic, what is the fittest way of training a technical electrician? The formidable array of studies which, according to Prof. Kohlrausch, the budding electrical engineer must follow, would result in a four or five years' course in the technical college. He must necessarily postpone all practical experience in the industry until he is 22 or 23 years of age, if he would master all the studies of the programme. The various problems in such a career were very cleverly stated by Prof. Kohlrausch with a sincerity and an earnestness that disarmed criticism. In the debate which followed Prof. Slaby, of Berlin, urged that the young electrician would be better if a year in the factory were intercalated in his five-year course of study, a view which the octogenarian, Prof. Rühlmann, supported in his inimitable style. Dr. Werner von Siemens declared that electrotechnics as a single science did not exist, and that there was a much greater demand for practical engineers than for technical electricians, who were the special products of the technical high schools. It did not seem to occur to any of the speakers that there was current in England a wholly different mode of producing an electric engineer, or that there could be any advantage in a course of five years' training in the industry, with, perhaps, a year in a technical college intercalated in the time of pupillage. This debate having come to an end, the assembly was pleased to listen for forty minutes to the reading of a Paper on the new domain of alternating currents by the writer, and then adjourned for lunch. Amongst other matters of business, it appointed a committee, under the presidency of Prof. Kittler, of Darmstadt, to discuss certain propositions relating to the legal questions arising from the interference with telegraphs and telephones of the strong currents used in lighting and tramway work. This matter, indeed, appeared to be the one burning question brought before the Congress. Whenever the topic was approached it aroused the attention of a large number of engineers present at the Congress. Petitions to the Reichstag, prepared for signature, and drafts of Bills to be presented, were freely handed about. The committee held several lengthy sittings during the following days, but finally presented to the Congress a report, which was accepted unanimously without amendment. This report leaves matters very much where it found them. Its elaborate propositions virtually declare that there is no scientific neces-

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sity for such interference between different electrical systems, and that where such interference arises the common law provides a sufficient remedy. Further, that it is impossible to set up a valid distinction between strong currents and weak currents, or to restrict the use of earth returns to either class of circuit. It is doubtful whether English electricians would acquiesce in so vague a settlement of the question.

The sectional meetings into which the Congress resolved itself were held in various localities, and usually simultaneously, so that it was impossible to get an adequate notion of the proceedings of them all; and in some cases the long time occupied by some one speaker caused a dislocation of the programme. Thus, for example, an extremely interesting Paper by Dr. Holborn, of Charlottenburg, on the magnetic properties of steel hardened and tempered under various precise conditions, was listened to by a comparatively small audience, owing to the time of its reading having been changed. To the sectional proceedings of Tuesday and Wednesday further reference will be made later. The evening of Wednesday closed with a banquet in the hall of the Palm Garden, Dr. Werner von Siemens presiding. This banquet, which was attended by about 500 persons, was noticeable for the warmth of welcome accorded to the speeches of foreign visitors, notably that of Prof. Ferraris in proposing the toast of the City of Frankfort.

The second general assembly was devoted to Papers on a standard gauge for screw threads by Dr. Löwenherz, Director of the Imperial Institute for Physical Research at Charlottenburg, and on Notations and Symbols, by Monsieur Hospitalier. The work accomplished in England, by Whitworth, in heavy engineering, and by the Royal Microscopical Society, in unifying the screw thread used for microscopes, is regarded in Germany as of enormous value. The Sellers thread used in America does not appear to be acceptable on the Continent, where Whitworth gauges are preferred. But for fine screws there is no accepted gauge; and Dr. Löwenherz's proposition was to found a new scheme on the basis of the metric system, apart from which he declared no gauge to be acceptable. Monsieur Hospitalier advocated the adoption of a system of symbols, formulæ, and nomenclature which should have international validity, and made several suggestions towards such a system. In the discussion which followed, Mr. Uppenborn referred to the difficulty created by the difference in value between the British horse-power as defined by James Watt and the metric horse-power which had been devised as a Continental equivalent. The playful explanation of an English member that a British horse could work harder than a metric horse was received in good humour; and the subject of notations was then by common consent referred to a committee, with Prof. Ferraris as chairman, to bring up a report. At this sitting a formal proposition was circulated by the American delegates, proposing the adoption of the name of "henry," in honour of Prof. Henry, for the practical unit of coefficient of self-induction, which has hitherto been known as the "secohm" or the "quadrant." This proposition was also remitted to the consideration of the Sectional Committee. Another discussion arose upon a Paper by Dr. Oscar May on the proper regulations about electric conductors from the point of view of the fire insurance companies. For English electricians the debate on this question had little interest in the absence of the ever vigilant engineer of the Phœnix Fire Office, without whose opinions no discussion on fire regulations can be considered complete.

At the third and final general meeting on Saturday, 12th inst., reports were received from the Sectional Committees and discussed. If it were permitted to raise the veil from the meetings of these committees, much might be told of the extraordinary and lively spirit of good fellowship which pervaded even the most animated discussions. When a dozen eager electricians come together from various nations, and insist on making their opinions known in half-a-dozen different languages in rapid succession, and each harangues and expounds in his own and other languages in turn, the result becomes at times indescribable. The Committee on Notations, while not accepting the whole of M. Hospitalier's suggestions, found themselves able to agree upon a report which was eventually passed by the general assembly *nemine contradicente*. Translated into English it runs as follows:—

I. The Congress decides that—

1. Physical quantities are to be denoted by italic letters;
2. Units are to be denoted by Roman letters;
3. Physical constants (coefficients relating to specific properties of materials) and angles are to be denoted by Greek letters.

II. The Congress decides: That whilst it recognises the following names, "joule" for the volt-ampere-second, and "watt" for the volt ampere—names fixed by the International Paris Congress in 1889—the practical electrical units shall be represented by means of the Roman capitals which constitute the initial letter of their respective names, viz.:—Ampere, A; coulomb, C; farad, F; joule, J; ohm, O; volt, V; and watt, W.

III. Whereas M. Hospitalier has elaborated a system of notation which, in his opinion, is capable of designating all the physical quantities which are of any practical importance (without introducing any needless change), we recommend to the members of the committee named by the Congress that they should kindly put to practical test the system (which the committee considers of material value), and at the end of the present year publish in the technical journals the results of their examination, in view of arriving at a common agreement; and we leave to the next Congress the definite adoption of these symbols.

On the American proposal to adopt the name of "henry" for the unit of self-induction no conclusion was arrived at by the committee. Though a majority appeared to be in favour of the proposal, it was strenuously resisted by Prof. H. F. Weber, of Zürich, who did not seem to be aware of the magnitude of Henry's researches of 1831. He proposed instead the name of Neumann, who in 1845 did so much to perfect the theory of variable currents by introducing the expressions for the self-potential of a circuit into the differential equations. Neither did the committee agree upon another proposal to adopt as the practical unit of magnetic flux the "gauss" equivalent to 10^8 C.-G.-S. magnetic lines.

After disposing of these matters the assembly listened to Herr Zipernowsky's project for a rapid-transit electrical railway between Vienna and Buda-Pesth, a distance of 200 miles, to be run in less than two hours. No one seemed to doubt the electrical arrangements, but wind-friction seemed to be a bugbear. The last Paper was by Dr. Epstein, of Frankfort, on "Institutions for Research and Standardising, similar to the Reichsanstalt at Charlottenburg," and was followed by a discussion as to the character of certificates which such establishments should issue.

In the Sectional proceedings many interesting and valuable communications were made. Unfortunately, most of these were given *viva voce*, printed copies of them not being obtainable. A notable exception occurred in the case of the Paper read by Mr. Preece on the progress of telegraphy and telephony in England, printed copies of which (in German) were handed about at the time of reading.

The first section was devoted to instruments for measurement and theoretical matters. Dr. Koepsel, one of the staff of Messrs. Siemens and Halske, discussed existing modes of measuring currents. Dr. Lindeck, of the Imperial Research Institution of Berlin, narrated his experiences with standard cells of various types. Professor Quincke, of Heidelberg, described and showed a very simple and cheap form of instrument, which could be used either as a magnetometer or as a galvanometer of various degrees of sensibility. It consisted, briefly, of a light magnet attached to a mirror of rather larger size than is usual in mirror galvanometers, suspended by a cocoon fibre in a circular hole cut in a vertical glass disc about a foot in diameter. A paraffin lamp threw a spot of light upon a scale. Various coils could be used with the apparatus. To those accustomed to the many patterns of mirror galvanometer used in English laboratories the apparatus presented little novelty save in the extreme simplicity of its parts. But to German electricians, accustomed to the cumbrous "subjective" mode of reading by means of an observing telescope, the apparatus afforded a rapturous delight, increased doubtless by the delicate sarcasms at the ways of professional instrument makers, which Prof. Quincke interwove in the most

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charming manner with his description. Other contributions to the topic of instruments were made by Dr. Bruger and Prof. Feussner. The latter has been doing good work on the subject of some new alloys for resistance coils, and their various temperature co-efficients.

Dr. Du Bois described a most elegant magnetic balance for weighing, by a species of steelyard, the magnetic permeabilities of pieces of iron; and he showed how to discriminate between the reluctance arising from shape, and that due to specific properties of the material. Dr. Holborn spoke of his researches on steel for magnets, which led him to the conclusion that even the best sorts of steel will not make good retentive magnets unless particular care is taken to harden the steel at the temperature proper to each brand, and to temper it in a sufficiently precise mode. Prof. H. F. Weber gave a long and most elaborate account of his researches on the general theory of incandescent lamps, and described the results of an exhaustive examination of a large number of lamps manufactured by different makers. He finds the temperature of the radiant filament to be nearly always about 1570° C.; a lamp which when shining with 1 candle power had a temperature of 1400° only rose to 1600° when it was over-run to 32 candle power. Lamps with black filaments showed a slightly higher radiation coefficient than those with grey graphitic filaments. It was a comfort to learn finally that the economy of all lamps—apart from their length of life—is the same for all, and depends in nowise on their mode of manufacture. One of the most interesting of all the communications was by Dr. Voller, of Hamburg, upon the propagation of electric waves in conductors. He has followed up the experimental work of Hertz, and extended it in a series of beautiful demonstrations, in which using exhausted tubes, which become luminous so that a whole audience can see them, he showed the existence of nodal points in the electric waves.

The second section, to which was allotted the topics dealing with strong currents, met in an annexe of the restaurant at the Exhibition, a room almost unendurable by reason of heat and noise. In this section Herr Geist spoke of dynamometric apparatus, and Herr Baumgardt discussed the relative advantages of compressed air and electricity for transmitting power. Mr. Kapp explained the method of measuring the various losses in armatures due to hysteresis, friction, and eddy-currents, which was simultaneously worked out a few months ago by him and by Mr. Housman. It appeared to be novel to our Continental brethren. Even the jury of the Exhibition did not propose to apply this simple method to testing any of the dynamos. But the main interest in this section, as indeed of the whole Congress, centred in the topic of the multi-phase alternate current, or *Dreh-strom*, as it is familiarly called. Herr M. von Dolivo-Dobrowolsky (who is associated with Mr. Brown, of Oerlikon, in the Lauffen-Frankfort transmission of power) spoke of his work with alternate-current motors, and explained the principle of his rotary-current motors, the largest of which, of nearly 100 H.P., receives the current from Lauffen, and pumps water for an artificial waterfall. He based his explanations respecting phase-differences of the alternations of voltage and current upon the device of supposing the actual current to be split into two currents, one in precise phase with the voltage (which he termed a "working" current) and the other in quadrature with it, which he termed a "watt-less" current. In the discussion Messrs. Déri, Korda, and Kapp, and also the writer, took part. Other distinct communications on the topic of alternate-current motors were made by Herr Goerges, of the firm of Siemens and Halske, and by Herr W. Lahmeyer, of Frankfort. It should be mentioned that polyphase motors (or rotary-current motors) are shown in the Exhibition by all the firms represented by these gentlemen, and also by Schuckert, of Nürnberg; and that there was quite an *embarras de richesses* of rotatory transformers for changing alternating currents into continuous, and *vice versâ*. Mr. Lahmeyer diverged from alternate-current topics into the transmission of power by continuous currents. His firm is showing in Frankfort how power may thus be transmitted from the suburb of Offenbach, some eight miles away. Mr. Lahmeyer proposes to obviate sparking in dynamos by introducing resistance in the connections between the sections of the armature windings and the bars of the commutator. Mr. Guttmann, of New York, described the success which had attended the introduction of Tesla's motors on the rotary-current principle.

In the third section, dealing with telegraphic and telephonic matters, there was the Paper of Mr. Preece, already referred to, and a brief but interesting communication by Geheimer Postrath Grawinkel, of the Berlin Post Office, on the use of Tudor accumulators for telegraphic purposes. He found the average current to be but one milliampere per line. Dr. Strecker, also of the Berlin Telegraph Department, described a telephone time recorder to enable the department to charge the users of telephones in proportion to the time that they used the instruments. Dr. Julius Maier, of London, read a Paper on "The State Control as contrasted with Private Control of Telephones;" and the author described the Phonopore of Mr. Langdon Davies, which on this occasion was connected up from the Exhibition to Homburg on the ordinary telegraph lines simultaneously with the ordinary telegraphs. It appeared that the phonopore telegraph was making its way as a useful adjunct to railway telegraphs, converting omnibus lines into trunk lines without interfering with ordinary working.

The fourth section dealt with electro-chemistry and miscellaneous applications, such as the adaptation of electric appliances to mining machinery. It appeared that Mr. Van Depoele and Mr. Atkinson had independently devised reciprocating rock drills by the combined use of continuous and alternate currents on a plan published some years ago in an elementary form by Dr. Werner von Siemens.

Dr. Zerener discussed the processes of electric tanning, and Mr. Pfutzner the process of electrolytic refining of copper, as used by Siemens and Halske.

One of the most memorable features of the Congress was the subsequent excursion to Lauffen to view the turbines, dynamos, and transformers, by means of which the current is transmitted to Frankfort over a line 108 miles long. As the line runs for almost its whole length along the railway, the excursionists had abundant opportunity for observing the manner in which the three wires are carried on oil-insulators on lofty poles. The interest of the occasion was enhanced by the presence not only of several members of the Prussian Ministry and of State officials from Switzerland, Würtemberg, Baden, and Hesse, but also of M. Marcel Deprez, Prof. Ayrton, Prof. Ferraris, Colonel Huber, Director of the Oerlikon works, Herr Rathenau, Director of the Allgemeine Company, Postrath Ebert, who superintended the erection of the line, Oscar von Miller, who engineered it, Baurath Lindley, of Frankfort, and of Messrs. Dolivo-Dobrowolsky and C. E. L. Brown, who designed the motor, the dynamo, and the transformers. The party admired the generating dynamo designed by Mr. Brown and constructed at the Oerlikon works, the most mechanical, surely, of all dynamos hitherto put together. They looked at the transformers and inspected the testing laboratory erected for Prof. Weber and his assistants. Then they enjoyed the hospitalities of the two Companies—the Allgemeine Elektricitäts Gesellschaft, of Berlin, and the Oerlikon Maschinenfabrik, of Zurich—who have collaborated in this intensely interesting experiment; and returned in their saloon carriages to Frankfort, conscious of having visited the scene of the most remarkable electrical experiment of the century.

If the Congress of 1891 had had no other result than to bring together so many electricians and engineers to discuss, day by day, the progress of their common science, and to learn to esteem and value one another, it would have done a useful service. But it did more than this: it showed how an important scientific experiment can be carried out on a large scale by the co-operation of public authorities with private industrial bodies. The Lauffen-Frankfort transmission would have been simply impossible but for the enlightened and spirited way in which the German Postal Telegraph Department lent its powerful aid to forward a scheme requiring the assent not only of various local bodies, each exercising local government in the territories traversed by the line, but also of the railway companies and other corporations. The success of this enterprise is a lesson in many ways, not only to the electricians, but to the telegraph departments of other countries.

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ALTERNATING CURRENT ELECTRIC SUPPLY STATIONS.*

BY DR. J. A. FLEMING, M.A.

§ 1. **The General Design of Alternating Current Stations. Motive Power. Selection of Unit.**—In the general design of a system of electric supply by alternating currents, as at present carried out, many considerations have to guide the engineer in the selection of a suitable site, and in the choice of the motive power and the arrangement of the generating plant. At the present time (1891) the selection of a system of electric supply to be adopted for electric lighting of towns is practically limited to one of two systems. First, the system of direct supply, with or without secondary batteries, on the two, three, or five wire systems; and, secondly, the system of alternating current supply, including the so-called rotary field (Drehstom) systems, on the general lines of one or other of the plans described in the previous chapter.

The system of two-wire direct current low-pressure supply is one that is suitable for small districts in which the lighting is dense, and in which the supply station can be placed approximately in the centre of the district to be lit. Experience shows, however, that the economical limits of such a system are reached when the mean length of the feeders is some 300 or 400 yards. By the three-wire system, as developed by Mr. Edison and Dr. Hopkinson, the system of low pressure supply can be economically conducted when the mean length of the feeders is from half to three-quarters of a mile. The five-wire system is applicable up to a mean distance of one mile. Beyond this distance, we are practically limited to a system of supply based upon alternating currents and transformers. Assuming, then, that the case to be dealt with is one in which the above facts point to the employment of the alternating current system, the first consideration to which the engineer has to address himself is the selection of a suitable site for the station. It will generally be found that the choice is limited to two or three positions, and that questions of convenience, price of land, access, nuisance, and other circumstances bind down the engineer to the selection of one out of a small choice of possible sites. Assuming, however, that an option exists between one or more positions for such an "eccentric station," then the following considerations should have due weight in determining the exact choice to be made.

In the first place, the selection ought to be governed by the consideration of convenience of access for coal and of freedom from creating nuisance by smoke, steam, or vibration. At the outset, when the supply from such station is small, the amount of coal and other stores to be brought into it, and of ashes, &c., to be removed, will not present formidable difficulties, but as the station grows in magnitude this will prove to be one of the most serious items in the economical management of such a station; hence, wherever a river-side or water-side site can be procured, by which coal can be received and ashes removed by water, a great advantage is secured, even omitting, for the moment, the advantages of condensation of exhaust steam.

As every thousand units of electric energy sold involves a combustion of from 4 to 10 tons of coal according to the system of alternating current supply adopted, it is obvious that convenience for handling coal and discharging ashes is of paramount importance, and that interruptions of this work by any conditions of weather ought to be practically impossible. With this object the engineer will naturally provide, under these circumstances, for convenient access by road; also, if possible, a connection with a railway siding, and will see that, in addition, a storage for coal is provided, to render it feasible to purchase and store two or three months, supply of coal, thus rendering the station independent of strikes or trade complications. Assuming that such water-side site is procurable, the next question is the general design of a station. In this matter the greatest possible mistakes have been made in many existing stations, either in designing them on too small a scale at the beginning, without sufficient provision and arrangements for extension or else in designing them at first on too large a scale. The object to be aimed at should be to lay down the station on such general lines that it is capable of considerable extension, as required, without in any way interfering with the existing plant or interrupting the current supply, but at the same time not to involve the enterprise in its initial stage in too large a capital outlay in buildings, on which at first no adequate return can be made. In many cases electric lighting stations have been put up in a small and temporary manner, resulting in the necessity for entire rebuilding at great cost and inconvenience when the demand for current passes a certain limit. Accordingly, the best general design, wherever it is possible for such stations, is an arrangement in which the building is gradually extended from one end as required. If space is limited, this building may take the form of a single building of several stories, engines being placed on the ground floor, dynamos on the floor above, and boilers on the second floor, stores and offices on the third floor. If ground space permits, a cheaper building can be constructed, taking the form of two sheds, lying alongside or in line with one another, one forming the boiler house and the other the engine and dynamo room, arrangements being made at one end for stores, offices, fitting-shop, &c. The general design of such a station calls for great forethought in all the arrangements, in order to reduce in every way the amount of labour required. Want of prevision in this matter results very often in the erection of a station in which there is a considerable waste of labour, and this is an important item in proportion as the station grows in magnitude. Assuming that a careful choice has been made as to site, having regard to the considerations above mentioned, the next matter which demands careful forethought is the choice of the size of the unit of power and of the unit of steam generating plant, in other words, the sizes of boilers and the engines. On this question, there is at present considerable diversity of opinion. Some engineers prefer to select a large engine unit, guided apparently by the notion that such a large engine unit is more economical than a number of smaller ones of equal total power. This, however, has by no means been demonstrated to be the case. Apart from any other reasons it is clear that if the current supply to any one section of a district is wholly dependent upon one large engine, it is obvious that another of equal size, or equivalent, must be provided as a reserve, and hence 50 per cent. of the plant is always idle. If the unit selected is a smaller one then, provided that the alternators can be worked in parallel, it is possible to have a much smaller fraction of the engine and dynamo plant kept idle as a reserve. Moreover, a break-down throws out of use a much smaller proportion of the total power. The same, of course, applies to the boilers. Owing to the general nature of the load diagram of the ordinary electric lighting supply station, the maximum demand for current is very many times greater than the mean demand, and moreover the maximum demand from most supply stations exists only for a very small fraction of the whole 24 hours. The ratio between the total number of units sent out from the station in the 24 hours to the amount which would be sent out if the plant were working at its full capacity for the whole 24 hours is conveniently called the *diurnal load factor* of the station; and the ratio between the units sent out from the station in one year, and the total amount which would be sent out if the machinery worked always at its full power, is called the *annual load factor*. Experience shows that the annual load factor for an electric supply station, sending out currents for lighting purposes alone, is not more, in general, than eight or ten per cent. Accordingly, as is now well known, the great difficulty that the electric engineer has to contend with is the fact that for large periods of the 24 hours the generating plant is very lightly taxed, and under these circumstances, unless it is properly subdivided, the efficiency of generation will be very small.

In the selection of boilers the choice lies either between the boilers of the water-tube type, one of the locomotive forms, a modified marine boiler, or the well-known Lancashire boiler. The general cause of the small average net evaporative duty of boilers in stations having a small load factor is the necessity for lighting and firing up the several boilers for only short periods during the evening, so that there is an immense waste

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of heat from radiation and conduction as the boilers cool down after having been thrown out of use; such losses are of course increased when there are large masses of brickwork in direct contact with the fuel which have to be heated up. For this reason many engineers give the preference to forms of internal firing boilers, such as the locomotive marine boilers or the Lancashire. The use of the ordinary return-tube marine boilers has been limited, owing to the difficulty experienced in transporting them by rail when of large size. A modified form of marine boiler has been constructed by Davey-Paxman (*see* Fig. 1) for use in electric lighting stations. This boiler is known as the dry-back boiler; it is not more than 9 feet in diameter, and the furnaces are contained in two cylindrical flues crossed in advance of the firing bridge by a Galloway tube. The products of the combustion pass right through the back, are thrown upwards, and made to return to the front

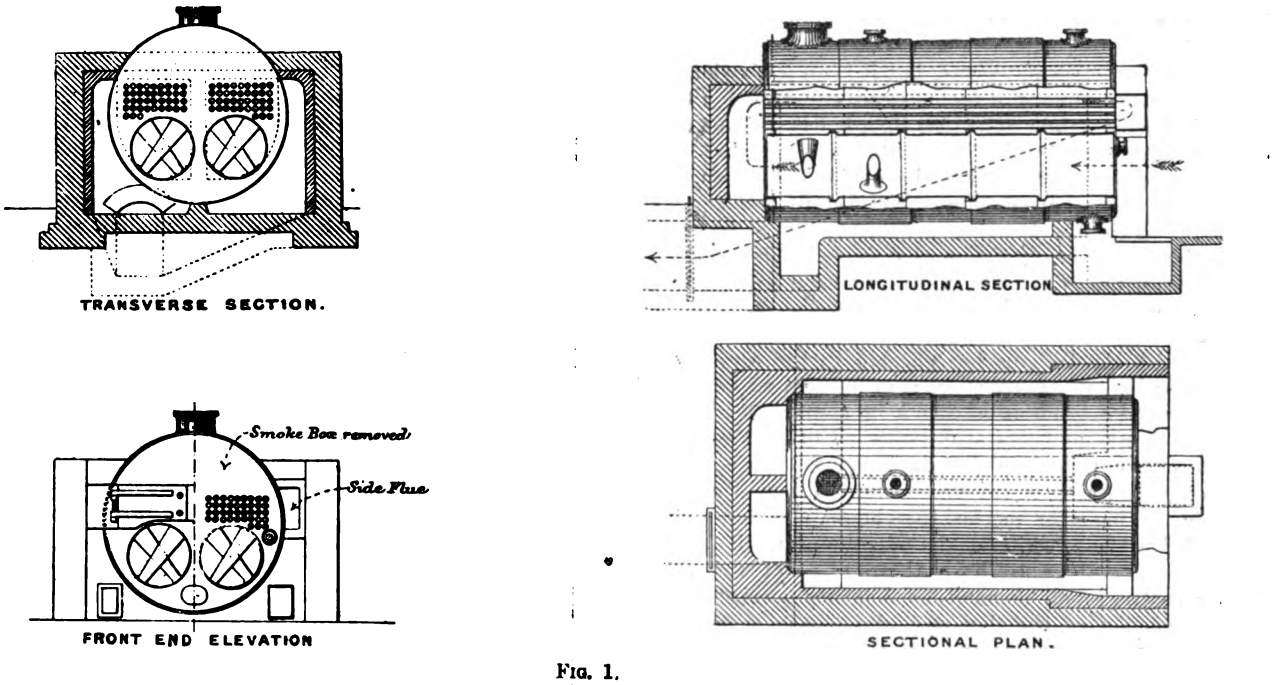

Fig. 1.

through the tubes by means of the refracted fire-brick dry-back. Mr. Crompton and Mr. Longridge have modified this form of boiler by placing the tubes below the furnaces. The products of the combustion, after passing to the end, are thrown downwards by the fire-brick dry-back, and then passed back to the front of the boiler through tubes placed below the

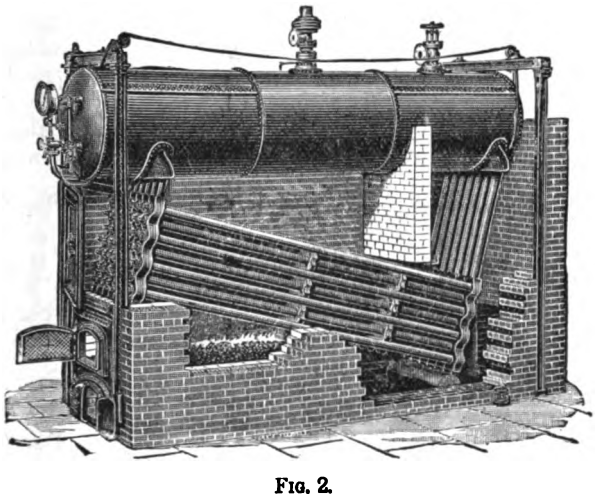

Fig. 2.

furnaces to the smoke-box or chamber formed beneath the fireman's feet, from whence they pass under the bottom of the boiler on their way to the chimney stack.

Other engineers prefer, where space permits, the employment of the ordinary Lancashire boiler. Formerly difficulty was experienced in making flues of sufficient strength to withstand the high pressure now required; but as this difficulty can, and has been, overcome, this objection is not now valid. On the other hand, the length of this boiler is an insuperable objection to its use in many cases. Amongst well known water-tube boilers used in electric lighting stations, the Babcock and Wilcox water-tube boiler, a section of which is shown in Fig. 2, is extensively employed. The great recommendations of this boiler are the rapidity with which it can make steam, and the fact that the limit of its evaporative power is only found in the ability of the grate to burn fuel. From its tubular construction it is very free from risk of dangerous explosion, and can easily be transported in sections and erected *in situ*; moreover, it is exceedingly economical as regards space, and from its rectangular form and great vertical height is specially adapted for batches of boilers in central station work where floor space is limited and costly. An objection which has been urged against it is the fact that there are considerable masses of brick-work to be heated up, and which, therefore, absorb and dissipate a sensible amount of heat. On the other hand, for central station purposes, where the demand for steam may, owingto fogs, suddenly become very considerable, it is of the greatest possible advantage to have a boiler which can be suddenly called upon for a considerable delivery of steam, and in which there is great safety and freedom from risk by explosion. Both these qualities are possessed by the Babcock boiler.

Mr. Raworth has suggested an arrangement intended to reduce the enormous waste of fuel in getting up steam in boilers which are used only during the maximum hours of demand. The boilers are erected in groups of three, with flues and condensers so arranged that when the central boiler is being used the products of combustion may be diverted through the furnaces and flues of one or both the other boilers. During the hours of light demand when the middle boiler alone is being used, the exhaust steam from the pumps and supplementary engine is turned into the idle boilers, until the water in them attains a temperature of 212°F., the additional heat required to raise steam being supplied by the products of combustion taken from the central boiler. When the steam in the idle boilers has risen to working pressure, they may, when required, be put into use and fires lighted; the gases from the central boiler being taken direct into the chimney. The method of applying the exhaust steam from the supplementary engines is as follows:—The supplementary exhaust pipe is carried across the whole range of boilers and a branch provided to each boiler, governed by a cock or screw valve. An outlet from the supplementary exhaust pipe is provided into the atmosphere covered

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by a mushroom valve of considerable size, weighted to 11b. to the square inch, and provided with an arm by which it can be raised to give free exit. The branch pipe to each boiler is attached to a block on the cover of the shell, and an internal pipe is carried down in continuation of the external pipe to about one foot below the working water level, where it turns at right angles to the vertical pipe, and is furnished with a circulating nozzle. When it is desired to heat up any boilers, the valve between the supplementary exhaust pipe and the boiler is opened, the exhaust valve to the atmosphere is closed, and the exhaust steam from the supplementary engines will be condensed in the boiler. As the water in the boiler increases in temperature the back pressure will increase, but will never exceed the 11b. to the square inch. In the case of water tube boilers, it is necessary to attach a distributing box to the discharge orifice of the nozzle, and to take from it pipes leading to each of the tubes in which the natural circulation is downwards. This is necessary to set up the circulation of the whole of the water tubes in the boiler. We are not aware that this plan has been put in practice anywhere, but it is an indication amongst others that the economy of fuel in steam generating is beginning to receive more serious attention than it has done at the hands of electrical engineers.

In the selection of engines the choice of the engineer lies between dynamos driven direct coupled to the engines, and those in which the dynamos are driven by belts or by rope gear, the latter being either the single endless rope-gearing with jockey pulley, or the multiplex rope gearing with the usual groove pulleys and grooved fly wheel. The direct driving has been considerably assisted of late years by the improvements which Mr. Willans has effected in the high-speed compound engine. Wherever space is of importance, direct driving by high-speed engines is almost a necessity. Where space is available many engineers still prefer to drive the dynamos in groups either from the fly-wheel of the engine or from a counter-shaft, owing to the lower engine speeds which are then possible. Whichever method be chosen, the first question to be settled is the selection of the dynamo unit. It is not necessarily an advantage to have these units of the same size. Owing to the small demand for lighting current during the greater portion of the day and night, it is generally best to select one pair of units (one being a reserve on the other), of such a size that one of them will be fairly well loaded during the greater portion of the day, and to select the other dynamo units of such larger size that the output of each machine is from one-sixth to one-tenth part of the full output of the station at its hour of maximum load during the winter.

The very poor economy which some stations exhibit in the matter of coal consumption may be also often attributed to the selection of too large an engine or dynamo unit. It must be borne in mind that compound non-condensing engines are not economical in steam consumption at low loads. It is found that at low loads indicator diagrams taken from high and low pressure cylinder show that the low-pressure cylinder is contributing very little to the total work of the engine, and under some circumstances the diagram of the low-pressure cylinder may even be a negative area, indicating that part of the power of the engine is being used to drive the low-pressure cylinder as a pump. It is, therefore, of great importance to select the engine and dynamo unit of such size that, under any circumstance, the generating plant in actual use is fairly well loaded. The theory that large engines essentially have a greater economy than small ones is not by any means generally true; and on the other hand, owing to the variation in the load, large non-condensing compound engines will often exhibit a relatively very much lower economy at the low loads in weight of steam used per indicated horse-power than smaller and well-designed high-speed high-pressure engines. Engines used for electric light work are under the great disadvantage that they must run at the same speed whether doing much work or little, and hence the only way in which the low station load factor can be neutralised is to give each engine individually as large a load factor as possible.

(To be continued.)

MAGNETISM IN IRON AND OTHER METALS.*—LI.

BY PROF. J. A. EWING, F.R.S.

(Continued from page 547.)

§ 176. **Retentiveness and Residual Magnetism.**—An equally satisfactory agreement is found when the results of experiments on retentiveness are examined in the light of the molecular theory. We shall take advantage of the opportunity which this discussion of the theory affords to describe some of these results more fully than has yet been done.

In the first stage of the magnetising process, as has been already remarked, there is no retentiveness: the magnetism that is initially induced, under very weak forces, disappears entirely when the inducing force is removed. This accords with the view that the molecular magnets are then being as it were elastically displaced from a position of stable equilibrium, without rupture of the ties by which the initial grouping maintains itself, so that each molecule simply returns to its primitive position when the displacing force is withdrawn. Theory and experiment alike show that this condition persists only so long as the susceptibility is very small.

In the second stage the susceptibility has become much increased as a consequence of the large deflection the molecular magnets suffer in breaking away from their original grouping to form new combinations. The movements they then accomplish are in great measure irreversible, that is to say, they are not undone as the magnetising force is being withdrawn. We may therefore expect to find a rapid development of residual magnetism during that part of the magnetising process in which the susceptibility is high. The theory shows that in favourable cases nearly the whole of the magnetism acquired during that stage will persist as residual magnetism. Experimental instances of this are given below.

The third stage, on the other hand, contributes little to the residual magnetism, for the molecular deflections that occur in it are for the most part undone as the magnetising force is withdrawn. A result of this is that the residual magnetism approaches saturation sooner (that is, under the action of weaker magnetising forces) than does the induced magnetism.

Another result is that the residual magnetism has a saturation value which is definitely less than the saturation value of the induced magnetism. It is indeed possible to imagine a molecular structure such that all the magnetism of saturation would be retained on the withdrawal of the force. This would be the case in a cubical formation if the lines of centres were parallel and perpendicular to the direction of the field throughout the whole piece. But the imperfect homogeneity of any actual piece of iron puts such a conception out of court, and when any of the lines of centres are inclined to the field, it is clear that the saturation value of I_r is less than that of I. It will be shown presently that a continuous cubical formation with lines of centres uniformly distributed as regards inclination is a structure which gives more than sufficient possibility of residual magnetism. The value of I_r, which the theory shows to be possible in such a structure, is in fact greater than the values which are found in experiments with even the most retentive metal.

The molecular theory makes it easy to understand the difference between retentiveness and what may be called coercive capacity, by which is meant the quality that the coercive force (§ 47) measures—the quality in virtue of which a substance holds its residual magnetism so strongly that a large magnetic force, acting in the reversed direction, is necessary to remove it. Retentiveness, on the other hand, is the quality in virtue of which much residual magnetism is held, though it may be held very weakly. Probably no magnetic substance has so much retentiveness as soft annealed iron, and probably none has so little coercive capacity. Retentiveness, by the molecular theory, is the result of a regular molecular structure of such a kind that the molecules readily arrange themselves in lines which are but little inclined to the direction of the applied force. The molecular ties may, however, be extremely weak. Coercive capacity is a result of strong ties, such as might be formed by reducing the distances between the mole-

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cular centres or between some of them, and this condition may very well exist in a structure where the lines are unfavourably arranged for retentiveness.

§ 177. **Experiments on Residual Magnetism in Iron.**—The following experimental results* were obtained with straight iron wires, 400 diameters long, using the direct magnetometric method. The magnetising force was gradually raised to an assigned value, then gradually withdrawn, to allow the residual magnetism to be noted; then raised to a slightly higher value, again withdrawn, and so on; so that the values of I and I_r were ascertained, corresponding to successive steps in the magnetising process. The results will be seen to bear out what has just been stated, and to furnish strong evidence in favour of the theory that the constraint of the molecular magnets is due to their mutual magnetic forces.

Table XXX.—*Induced and Residual Magnetism in a Soft Iron Wire, Annealed and Hardened by Stretching.*

Before stretching.				After stretching.			
H	I induced.	I_r residual.	Ratio of residual to induced.	H	I induced.	I_r residual.	Ratio of residual to induced.
0·42	16	3·9	0·24	0·42	3·6	0	0
0·58	24	6·6	0·27	0·99	13·1	2·9	0·22
0·70	33	9·9	0·30	1·44	21·1	6·5	0·31
0·99	62	24	0·40	1·73	26·9	11·8	0·38
1·16	91	46	0·50	2·14	41	15·3	0·38
1·30	140	85	0·61	2·88	72	32·7	0·46
1·44	195	133	0·68	3·58	116	61·7	0·53
1·58	280	209	0·74	4·20	167	98	0·59
1·76	364	283	0·78	4·90	218	132	0·61
2·02	468	380	0·81	5·76	265	167	0·63
2·14	507	418	0·82	7·20	359	225	0·625
2·28	549	455	0·83	10·78	566	327	0·58
2·51	614	513	0·84	11·90	613	348	0·57
2·74	673	568	0·85	15·20	751	381	0·51
2·88	702	598	0·85	17·50	817	399	0·49
3·16	764	650	0·85	23·61	947	414	0·44
3·58	842	711	0·85	29·81	1017	417	0·41
4·20	926	783	0·85	35·71	1078	419	0·39
5·02	984	832	0·84	41·90	1114	419	0·38
5·76	1020	848	0·83				
6·46	1050	864	0·82				
7·20	1070	877	0·82				
8·64	1110	897	0·81				
10·26	1130	910	0·80				
11·91	1150	913	0·80				
17·50	1190	929	0·79				
23·61	1195	929	0·78				
35·71	1230	933	0·76				
45·51	1230	933	0·76				

Table XXX. gives the results of an experiment† in which an iron wire, 1·58mm. in diameter, was tested, first in the annealed state, and then after being hardened by stretching beyond its elastic limit. Inspection of the figures will show that the ratio of residual to induced magnetism, which is at

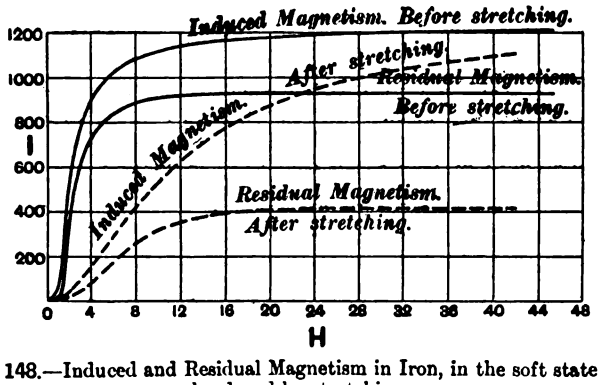

Fig. 148.—Induced and Residual Magnetism in Iron, in the soft state and hardened by stretching.

first small in both cases, rises to a maximum. This maximum, in the annealed wire, is so high as to imply that the rate of increment of residual magnetism is then not far short of the rate of increment of induced magnetism. The ratio afterwards falls off as the magnetising process passes into its third stage.

Fig. 148 is drawn to exhibit the same results. It shows well how the residual magnetism approaches its maximum faster than the induced magnetism, notably in the hardened wire.

* *Phil. Trans.*, 1885, Part II., pp. 556 *et seq.* † *Loc. cit.*, § 41, pp. 559-60.

This mode of representing the results, where I and I_r are given in terms of H, is not, however, well adapted to show what is the saturation limit towards which I_r is tending, nor what is the relative rate of increment of the two at various stages of the magnetising process. To bring these points out we may draw a curve showing I_r in relation to I (Fig. 149). We already know the saturation value to which I tends, namely, about 1,700 C.-G.-S. units (§ 98), and it is not difficult, by extrapolation of the curve in this new figure, to deduce an approximate value for the saturation limit of I_r.

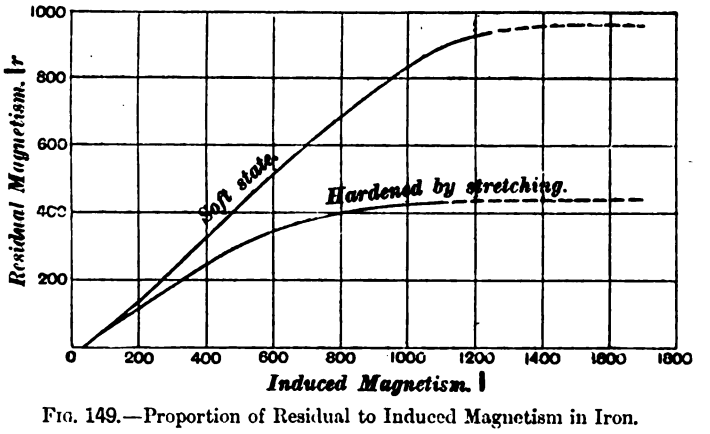

Fig. 149.—Proportion of Residual to Induced Magnetism in Iron.

This is done in Fig. 149, where the broken lines form a conjectural extension of the curves, beyond the range of the experiment, up to the saturation value of 1,700 for the induced I. It appears from these that the saturation values of the residual magnetism in this specimen are approximately 970 when the metal is annealed, and 430 when it is hardened by stretching.

An inspection of the curves in Fig. 149 will also show that after the initial stage in parts, in which the residual magnetism is acquired less rapidly, the proportion which the increment of I_r bears to that of I becomes nearly as possible constant, and remains so (in the annealed wire) throughout a large part of the whole process of magnetisation. From the point I = 150, or so, up to 800 the curve is practically straight, and during that part of the process nearly the whole of the magnetism that is acquired goes to form residual magnetism. By Table XXX. we have

H	I	I
1·30	140	85
3·16	764	650
Difference.....	624	565

So that, during this time, $\frac{565}{624}$, or quite 92 per cent. of the magnetism that is being induced contributes to the residual magnetism. After this the curve bends over rather quickly and $\frac{dI_r}{dI}$ becomes much reduced. In other specimens of annealed iron the value of $\frac{dI_r}{dI}$ during the steep stage was even more nearly unity.

This was the case in the experiment of Table XXXI., made with a piece of annealed iron wire 0·72mm. in diameter.* In this case a supplementary experiment was made to determine the influence of longitudinal pull on the residual magnetism. After the test made in the ordinary condition of no load, a steady load of 4 kilos. or 9·76 kilos. per sq. mm., was applied (a load well within the elastic limit), and the observations in the second portion of the Table were made. The proportion of I_r to I in each case is shown in Fig. 150, where the dotted line refers to the experiment in which wire was in a state of longitudinal tension. The full curve for no load is conjecturally extended to find the saturation value of I_r, which is higher in this specimen than in the last, namely, 1210. The rate of increment of I_r, relatively to I during the steep part of the curve is also greater, and the curve is prac-

* *Loc. cit.*, p. 629.

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tically straight throughout a wider range. The following figures will bring this out :—

I	I_r	Differences of I_r for 100 of I.	I	I_r	Differences of I_r for 100 of I.
300	232	—	800	722	99
400	328	96	900	822	100
500	426	98	1,000	921	99
600	524	98	1,100	1,020	99
700	623	99	1,200	1,100	80

Table XXXI.—*Induced and Residual Magnetism in Annealed Iron Wire, with and without Longitudinal Pull.*

Load = 0.				Load = 4 kilos., or 9·76 kilos. per sq. mm.			
H	I induced.	I_r residual.	Ratio $\frac{I}{I_r}$	H	I induced.	I_r residual.	Ratio $\frac{I}{I_r}$
0	0	0	—	0	0	0	—
1·08	66	32·5	0·49	0·54	38	21	0·53
1·62	202	141	0·70	1·08	141	94	0·69
2·16	460	381	0·83	1·62	325	242	0·745
2·70	684	601	0·879	2·16	532	419	0·788
3·24	846	767	0·907	2·70	677	543	0·802
3·78	939	860	0·916	3·24	796	640	0·805
4·32	990	920	0·921	3·78	876	705	0·805
5·40	1071	994	0·928	4·37	937	754	0·804
6·48	1109	1024	0·923	4·86	978	787	0·805
7·56	1139	1046	0·919	5·51	1022	816	0·800
8·64	1157	1063	0·919	6·48	1067	856	0·800
9·72	1168	1074	0·919	8·64	1121	891	0·795
10·8	1178	1082	0·918	10·8	1162	913	0·786
13·5	1196	1095	0·916	13·5	1186	926	0·781
16·2	1210	1105	0·913	16·2	1204	933	0·775
18·9	1219	1111	0·911	18·9	1211	939	0·775
21·6	1226	1116	0·910	21·6	1219	942	0·773
25·6	1236	1119	0·905	26·2	1232	946	0·768

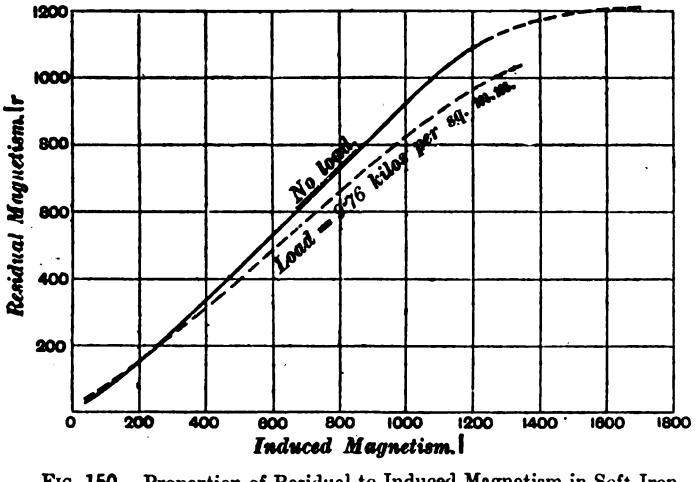

FIG. 150.—Proportion of Residual to Induced Magnetism in Soft Iron Wire.

It appears from these that in the stage lying between I = 300 and I = 1,100, or so, nearly 99 per cent. of the induction of magnetism was taking place by the turning round of the molecules into new lines, in which they remained when the magnetising force was withdrawn. Scarcely any of the induced magnetism was then being contributed by quasi-elastic deflections. After 1,100, the part played by quasi-elastic deflections began to be considerable.

In the test made while the wire was loaded the limit to which the residual magnetism apparently tended was about 1010. A feature to be remarked is that in the earliest stage the curve taken with load lies above the curve taken without load, crossing it when I is about 200. The presence of longitudinal pull, though unfavourable to the retention of magnetism by annealed iron when the magnetisation is strong, is favourable to it when the magnetisation is decidedly weak

Experiments made with other specimens gave results which agree well with these. With another piece of annealed iron wire 0·78mm. in diameter the following (amongst other) readings were taken :—*

* *Loc. cit.*, p. 559, § 40. Reference to the same Paper should be made for similar experiments with steel in the soft and hard states.

H	I	I_r	H	I	I_r
0·86	26	6	5·40	991	898
1·98	164	96	6·81	1,067	946
2·66	478	378	11·20	1,166	1,014
3·78	806	696	17·24	1,212	1,042

In this case between H = 2·66 and H = 6·81 the increment of I is 589, and that of I_r is 568 or 96 per cent. of the other.

One more experiment of the same class may be referred to in further illustration of the influence of longitudinal pull on the retentiveness of iron.† In this instance the piece tested, a wire, 0·72m. in diameter and 30·5cms. long, had been hardened by stretching beyond its limit of elasticity before the observations were made. Its retentiveness was then examined when without load and also when various amounts of steady pull were in action. The curves of I, also of I_r, each in relation to H, have already been given in Figs. 105 and 106 respectively; but the points to which attention is now directed may be better seen by reference to Fig. 151, where curves of I_r in relation to I are drawn for no load and for two values of the load. These show that a moderate amount of pull is very favourable to retentiveness in hardened iron, and greatly augments the saturation limit towards which I_r tends. A stronger pull, on the other hand, is less favourable, though under the greatest pull that was used in these experiments the wire continued to be more retentive than it was in the unloaded state. In a similar experiment made with steel wire, the amount of pull was further increased, and was then found to have an unfavourable effect, that is to say, it reduced the retentiveness in the upper range of the process below the value possessed by the unloaded wire.

In Fig. 151 the apparent saturation limit of I_r is about 460 when there is no load, and this is raised to 860 by the presence of a load of 12·2 kilos. per square mm. It is, of course very possible that a slightly greater or slightly less load than this would produce a still more favourable effect on

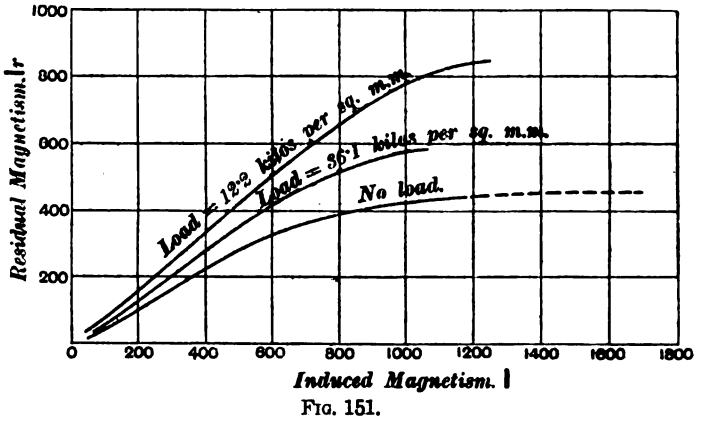

FIG. 151.

the saturation value of the residual magnetism. When there is no load the rate of increment of I_r with respect to I at the steepest part of the curve is about 0·7; but the presence of a suitable amount of load raises that to at least 0·85.

(To be continued.)

THE FRANKFORT EXHIBITION.—XI.

(FROM OUR SPECIAL CORRESPONDENT.)

The only two large alternating-current machines at the Exhibition are the 600 H.P. Helios machine and that of Messrs. Siemens and Halske. We give some details of the latter together with an illustration (Fig. 1), showing also the steam engine driving it. The machine is wound for 2,000 volts when running at 100 revolutions, and a maximum output of 330 kilowatt. The construction is very similar to that of the former machine of this kind built by the firm, the chief thing which strikes one about it being its enormous size. The

* *Loc. cit.*, pp. 625-8, § 110.

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armature is fixed and the magnets revolve within it. The armature is built up of sixty coils, wound on pieces of laminated iron and bolted to the frame. Each separate coil can, on removal of the machine casing, be unbolted, and easily taken away for repairs when necessary. The sixty magnet coils are wound on radial inwardly projecting teeth. All the conductors are stranded and pressed into a square shape, the copper wires being lightly insulated from each other by paraffin and varnish, the outer insulation consisting of paraffined fibre.

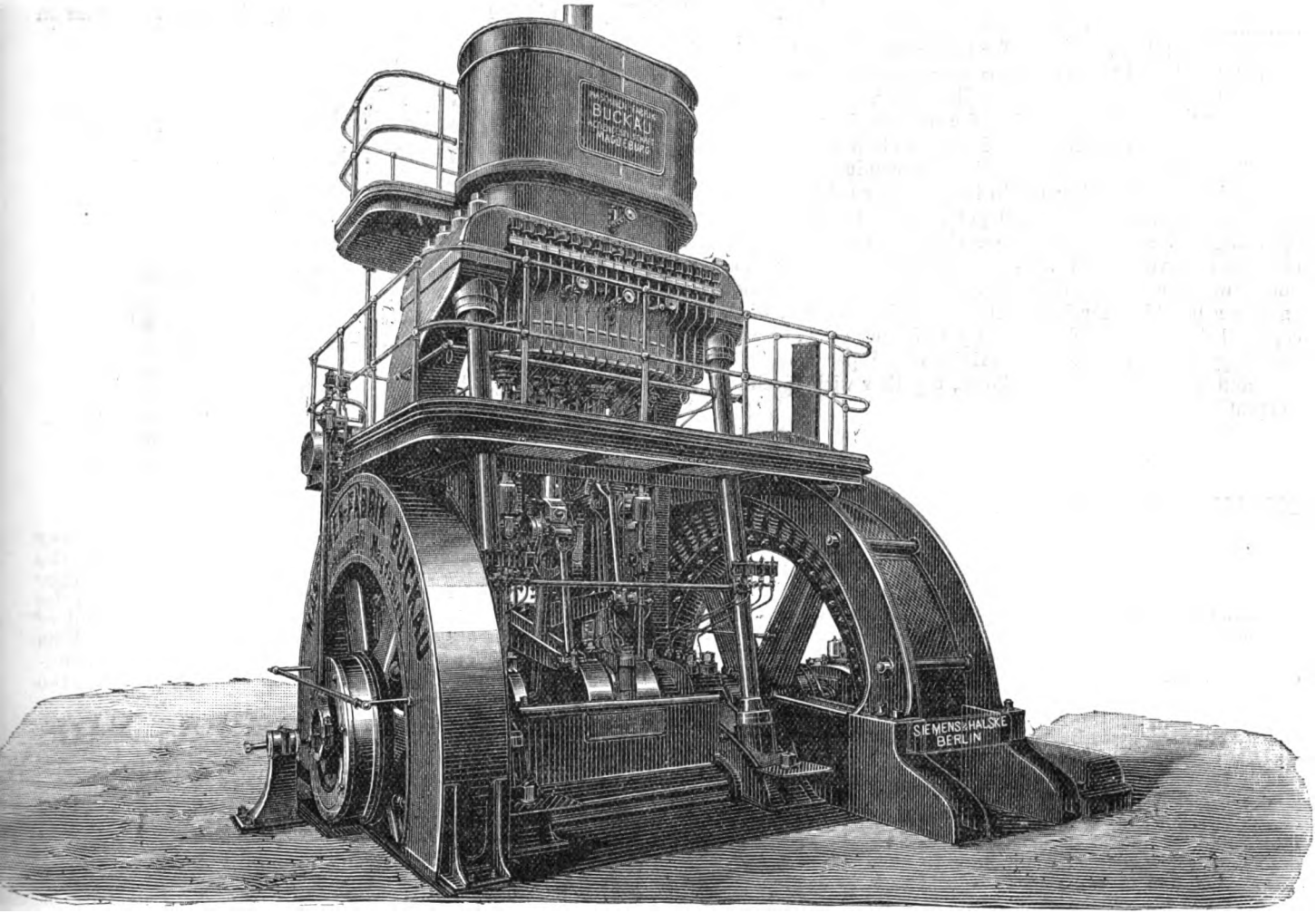

FIG. 1.

The alternator is coupled direct to the engine, and the lower part of the armature has a fairly deep space dug out in the ground for it, and sufficient room is left for the men to get down and clean or examine it. The diameter of the armature over all is nearly 15ft. 2in., while that of the magnet wheel is 8ft. less. The machine is chiefly used for motor-driving, the motors being used as transformers from alternating to direct current, the direct current being used chiefly to charge accumulators.

The 450 H.P. steam engine from the Maschinenfabrik Buckau-Magdeburg, driving the dynamo was not originally constructed for this particular machine. It was intended to run at 160 revolutions, and takes up comparatively small space. As will be seen, the two piston rods are very close together as also the cranks, and the effects of the ascending and descending masses of piston rod and cranks very nearly neutralise and balance each other, so that there is very little pressure indeed on the bearings. Thus comparatively high speeds are permissible. The cylinder diameters are 24·6 and 37·4 inches, and the length of stroke is 27·6in. The initial steam pressure is about 150lbs. per square inch, giving the engine 450 H.P. Grooves are cut on the flywheel to allow of it being levered into a favourable starting position.

The second illustration (Fig. 2) shows one of the three dyna-motors set up by this firm. The motor is of exactly the same construction as the generator just described, although on a smaller scale, and the continuous-current machine coupled to it is an interior four-poled machine of the type already described in these articles (*The Electrician*, August 28th). The usual apparatus is provided to show the right moment to put the load on to the motor, consisting of a small transformer with three windings, one to the generating machine, one to the motor, and the third to a glow lamp. In order to speed up the alternating motor, a battery of accumulators is connected to the continuous-current dynamo, which thus acts temporarily as a motor.

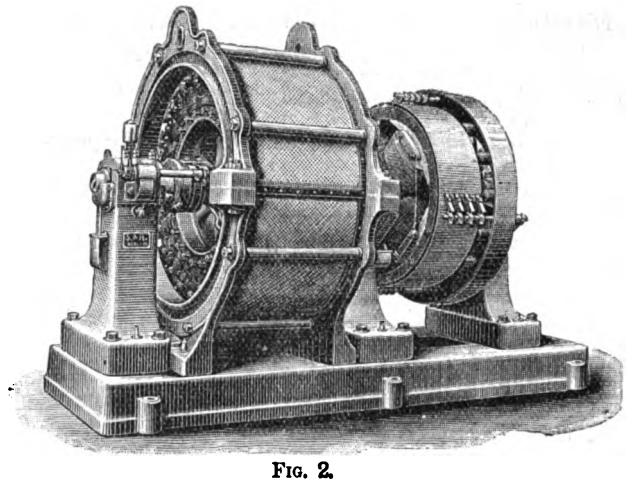

FIG. 2.

A very fine exhibit of wires, cables, and conductors of every kind is shown by Messrs. Felten and Guilleaume. Several examples of distributing boxes for the attachment of feeding

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and distributing cables on both two-wire and three-wire systems are shown, set in brick foundations, and finished with masonry setting; these are filled with insulating material, poured in hot, where the box is liable to be flooded. Several patterns of cast-iron joint-boxes and branch-boxes, both for ordinary and concentric cables, are exhibited. Lead-covered cables, with single and with concentric conductors, are made by this firm, who have provided for the latest requirements by manufacturing "biconcentric" cables for multiphase currents. A double covering of lead, put on by hydraulic pressure, is generally provided, and the lead is again protected, if necessary, by an armouring of round or flat iron wires, or iron tape. Numerous specimens of telegraph cables for underground and tunnel work are exhibited, and these are, in some exceptional cases, provided with a lead tube as well as iron sheathing. A new quality of their well-known bronze wire for telegraph and telephone purposes has been produced by Messrs. Felten and Guilleaume, who have succeeded in maintaining a conductivity to 60 per cent., while the breaking strain is as high as 44 tons to the square inch, allowing some 30 per cent. to be saved in weight by using a lighter wire having the same conductivity as the older and heavier quality. This firm are introducing the compound wire, having a steel core and copper sheath. The steel enables a breaking strain of 40 tons to be attained, while the copper brings the conductivity up to 55 per cent., or a 35-ton breaking strain with a conductivity of 75 per cent. Copper tape and wire of all sizes is shown, together with specimens of Ferranti cable and locked wire rope.

ON AN ELECTRICAL METHOD OF DETERMINING THE MECHANICAL EQUIVALENT OF HEAT.*

BY M. D'ARSONVAL.

I have the honour of describing to this Society a series of experiments undertaken by me to determine the mechanical equivalent of heat by transforming work into thermic energy by means of electricity. The heat liberated by an electric current, itself generated by a known amount of mechanical work, furnishes a simple means of measuring the mechanical equivalent. This method has already been employed by Joule at the commencement of his remarkable investigations in thermodynamics, and more recently still by M. Violle.† My work has, therefore, no other aim than to point out new devices permitting of a more accurate measurement of the power absorbed on the one hand, and on the other of the heat liberated by the disappearance of this energy. I have endeavoured more especially, in order to eliminate causes of accidental error and to avoid lucky coincidences, to devise a method permitting of the indefinite *accumulation* of the heat produced, and subsequent measurement of it by means of the balance. I have been able to attain this result by the calorimetric method communicated by me in 1877 to the Société Biologie, a method I have constantly employed since then in my researches on animal thermodynamics. In order to make clear what follows I will recall, in a few words, the principle underlying the method.

(i.) *My calorimeter does not heat, during the experiment it remains constant at the surrounding temperature.* I have, therefore, no correction to make, and I need not fear loss of heat by radiation.

(ii.) *The heat generated is automatically carried off, as its production goes on, by a stream of water, which flows into the apparatus at zero temperature and leaves it at the surrounding temperature of* T *degrees.*

To measure the heat produced it is, therefore, only necessary to weigh the water passed through the apparatus. Let P be this weight in kilogrammes, the number of Calories produced will then be given by the equation

$$C = P \times T.$$

We thus see that it is the compensating effect of the cold source which is the ultimate measure of the calories.

In another arrangement I have employed as the compensating source of cold the latent heat of volatisation of some liquid. In this the heat evolved distils the liquid *at the surrounding temperature*, and the change of state is not accompanied by any variation of temperature. I described this method to the Société de Biologie in 1878, and to the Société de Physique in 1880. I have, however, preferred the first method, because it answers in a more direct way to the very definition of the caloric, which is the raising of one kilogramme of water at 0°C. to 1°C. Moreover, the second method involves the previous determination of the heat of volatisation of the liquid, and in this method also a small error in weighing is more serious. The sensitiveness of the first method is, it will be understood, the greater the nearer the surrounding temperature T approaches to zero; while that of the second is almost independent of this. Moreover, the liquid does not always vaporise regularly. All these reasons induced me in the present case to measure the heat produced by the rise in temperature of a stream of water admitted at the temperature of melting ice.*

The various conditions are fulfilled in the calorimeter illustrated in Fig. 1, which I have employed in my different researches on

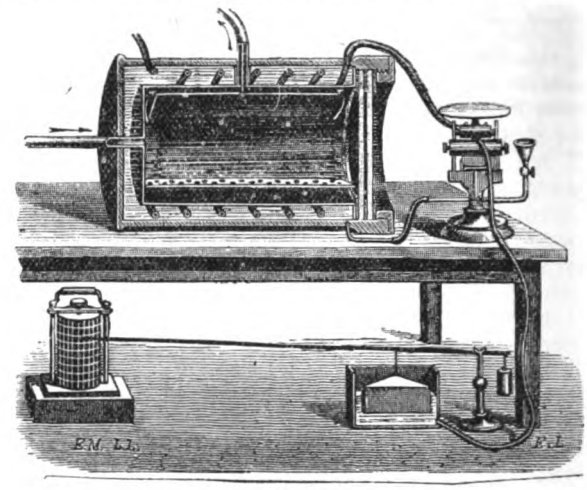

FIG. 1.

animal heat. The apparatus consists of two concentric copper cylinders enclosing two cavities; the central one containing the animal under test, the outer annular cavity containing a copper coil pipe, the left-hand end of which is in communication with the reservoir of water at zero temperature, and the right-hand end of which is in communication with the outflow regulator. This annular cavity is filled with a dilatable liquid which is in communication with the temperature regulator, which in turn regulates the flow of water through the coil.

The regulator (Fig. 2) consists of an india-rubber membrane, fixed horizontally on a block of metal by means of a ring provided with screws. The lower surface of the membrane is placed in communication with the dilatable liquid (petroleum) in the calorimeter by means of a metal tube, B, filled with water and terminated by a tap, C. On the upper surface of the membrane rests a metal piston,

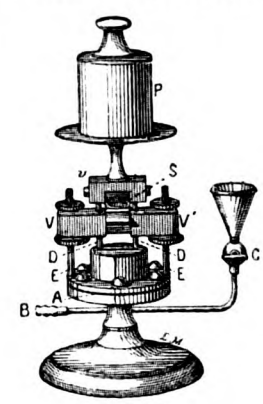

FIG. 2.

connected by the two vertical rods D D to a cross-piece surmounted by a tray, P, which can be weighted. These two rods pass through a second horizontal cross-piece, V V', which can be displaced vertically along the rods E E' and fixed in any required position by screws. To the top of the cross-piece, V V', is secured the thin india-rubber tube, S, which is in communication with the free end of the cooling coil.

* Paper read before the Société Internationale des Électriciens, March 4, 891.

† *Comptes Rendus*, 1870 and 1871.

* I have lately gone back to the distillation calorimetric method, substituting ethyl chloride for the sulphuric acid I used at first. The results obtained with this substance are very satisfactory. Ethyl chloride boils regularly without bubbling, its latent heat of volatisation is low, and its boiling point differs but very little from the average surrounding temperature. It is a very manageable substance, and has yielded good results in animal calorimetry, and is one which I hope to use also in the determination of the mechanical equivalent of heat.

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The working of the apparatus is easy to understand. The annular cavity of the calorimeter being well filled with petroleum, without air bubbles, the tap C is then opened so that the calorimeter may be in equilibrium with the temperature of the surrounding air, and the tube S closed by the weight P, so as to arrest all outflow. This done, the tap C is closed. If a source of heat is then introduced into the calorimeter, the temperature of the apparatus tends to rise, consequently the liquid (petroleum) expands slightly. This expansion causes the india-rubber membrane of the regulator to lift, raising the piston and slightly opening the india-rubber tube S. This allows a cold stream to flow through the coil, which carries off the heat given out by the source to be measured. This opening is effected gradually, without jerks, and the quantity of liquid which is flowing away at any instant is proportional to the heat given out. You can see by the illustration (Fig. 1) the simple method I employ to record the volume of water which has flowed, or rather to record the phases of the flow. This method of registration has no *raison d'être*, when, as in the present instance, it is a constant source of heat which we are concerned with.

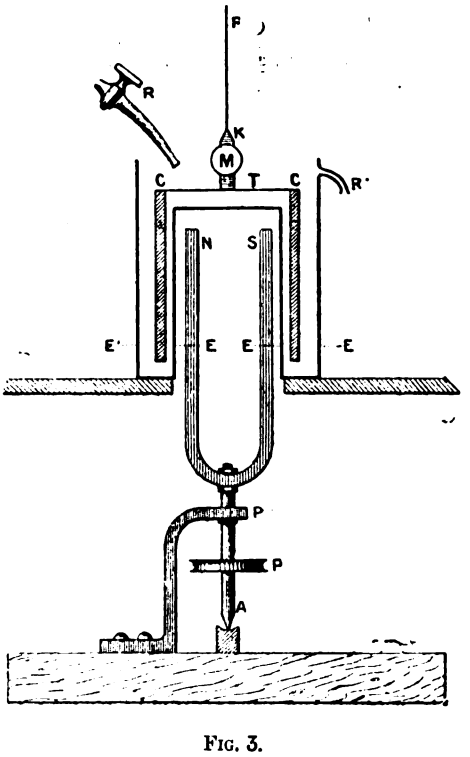

FIG. 3.

This method is accurate to a degree one cannot grasp at first glance. With the apparatus described, I can account for all but $\frac{1}{250}$th of the heat supplied. I may remark also that *the absolute error of the apparatus remains sensibly constant, while the relative error becomes smaller and smaller the longer the experiment is continued.* That is one of the great advantages of the method.

The method of measuring the heat having been described, I now pass on to the means employed to determine the power absorbed. The first idea of it occurred to M. Marcel Deprez, and is described in an account of a projected experiment communicated in our joint names to the Congrès de la Rochelle. The projected experiment was not then carried out, and in order to realise it I was obliged to completely alter the original arrangement, which did not permit of an easy measurement of the heat evolved.

The first apparatus I employed consisted of a thick seamless copper tube C C (Fig. 3), of ·06m. interior diameter, and ·15m. high, suspended vertically by the clip K from a steel wire. In the *interior* of this tube revolves a horse-shoe magnet, N S, which generated Foucault currents in the tube, tending to rotate it in the same direction as the magnet. The torsion of the steel wire, F, enabled me to measure at any instant the torque, that is to say, the energy absorbed by the tube; energy which is entirely transformed into heat in the tube itself, as has been well shown by the experiments of M. Violle with the Foucault disc. We can by this device measure the energy absorbed with extreme precision, since a mirror, M, allows us to see from a distance that the torque is constant by the lamp, scale, mirror method employed by Sir William Thomson in reading galvanometer deflections. The copper tube is plunged into an annular trough, E E, of ebonite, which forms the calorimeter, and which possesses the advantage of shielding the tube from the draught caused by the rotation of the magnet. It is possible to reinforce the magnetic field by placing an iron tube outside the copper tube, but inside the ebonite trough. This, however, is not necessary. I prefer to reinforce the field by substituting an electro-magnet of the Siemens shuttle-wound armature type for the permanent magnet, the coil being energised by a continuous current derived from a constant source (accumulators).

In order that the power absorbed may remain constant it is necessary (the magnetic field being constant) that the permanent magnet or Siemens coil should revolve at a constant speed. To attain this I employ the following mode of regulation:—A Gramme dynamo carries on the end of its armature spindle P (Fig. 4), a flat spring, R, bent into a circle.* This circular spring is fitted with two equal weights, M M'. A point, V, which is situated on the prolongation of the axis of the motor on the opposite side of the spring R can be screwed in and out as required. The current enters at V, and goes round the spring R to the motor. The armature revolves at an accelerated speed until the centrifugal force developed by the weights M M' flattens the spring sufficiently to break the circuit. To overcome the spark on breaking, I interpose a variable resistance, L, between B B'. If one likes one can send nearly the whole current through the shunt, and only send sufficient through the spring to regulate the small irregularities of speed due to irregular friction; the power demanded from the apparatus remaining constant in the present case. A machine developing 1 H.P. will not under these circumstances give the slightest spark when the circuit is broken at V. The screw, V, allows one to regulate the speed very accurately *during running*, and to promptly bring the torque exerted on the copper tube to a decimal value of a kilogrammetre.

The heat produced in the copper tube being a constant quantity, the calorimeter can be considerably simplified. It is, in fact, only necessary that the water which flows in at zero temperature should constantly flow out at the surrounding temperature. This can be ascertained by merely putting a thermometer at R' (Fig. 3), and regulating the influx accordingly by the tap R, which is in connection with a reservoir containing water at the temperature of melting ice and maintained at a constant level. The water flows

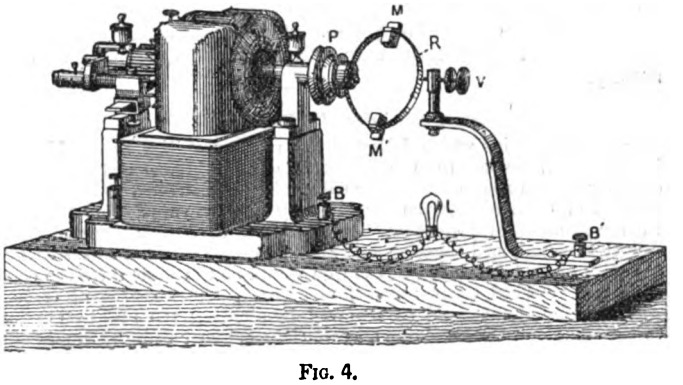

FIG. 4.

into the inside of the copper tube and goes round under it to flow out. The tube, being very thick and a very good conductor of heat, rapidly brings the temperature of the water inside the ebonite calorimeter to uniformity.

To eliminate the parasitic heating due to the friction of the air and the current in the Siemens coil, it is only necessary—the apparatus being at work—to take away the copper tube, keeping the current in the coil at the same time. A certain quantity of ice-cold water is found to be warmed up in a given time. The weight of this water is noted, and the experiment is recommenced with the copper tube. A different weight of water is now obtained, from which the first must be deducted. The difference gives the exact amount of heat absorbed by the copper tube.

The apparatus which I employed could absorb 3 to 5 kilogrammetres per second.† I worked in a basement, where the temperature during winter remained very nearly constant at 10°C. I obtained for the mechanical equivalent values which varied from 419 to 427 kilogrammetres.‡ I only regard these values as a first, though satisfactory, approximation to the truth. I intend to continue these researches with a somewhat different arrangement, capable of absorbing 4 to 5 H.P., and I am in hopes of eliminating, by the large scale of my operations, certain causes of error which I was unable to avoid with the first apparatus.

To obtain regularity of speed I also tried the following arrangement, which might be useful in chronographic experiments. A

* The idea of regulating the speed of an electric motor by making use of a centrifugal governor to break the circuit is due to Helmholtz. Since 1843 it has been applied in different ways by a number of people. The method I propose here has in its favour its great simplicity, and above all the possibility of regulating while running.

† 1 kilogrammetre = 7·2331 foot-lbs.

‡ [Mean value of previous determinations, 423·845. Ed. *E.*]

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tuning-fork (50 double vibrations) is placed in connection with the middle N (Fig. 5) of a battery of primary or secondary cells through an alternate current motor M. The ends of the battery are joined up to two adjustable screws, V V', placed exactly opposite each other. The tuning-fork is fitted with an elastic strip L, which, while the fork vibrates makes contact alternately with V and V'. A small electromagnet, E, keeps up the motion. It is easy to see by the diagram that the motor M will be traversed by absolutely regular alternate currents, with which it will synchronise. The whole trick (*tout l'artifice*) consists in having converted the electrical tuning-fork into a current reverser by merely connecting it to the middle of the battery. As to the motor one can use a Siemens alternator with shuttle-wound armature, although it would be better to use one without iron in the armature similar to the commercial type of machine. In the research we are now concerned with I preferred the apparatus with the circular regulator

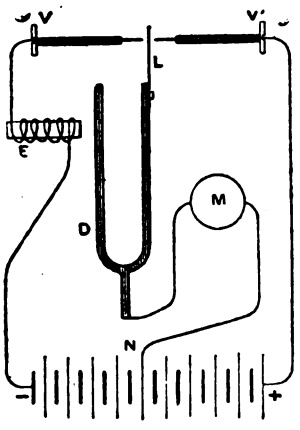

FIG. 5

shown in Fig. 4, owing to the large power which it can regularly develop. I am continuing this experiment with much greater forces, and I shall hasten to communicate my results to this society.

DISCUSSION.

In the discussion which followed the reading of the Paper, M. CARPENTIER referred to the Foucault currents developed in the iron cylinder placed round the copper tube. It did not seem to him that the method of determining the parasitic heating by suppressing the copper tube was altogether correct. The Foucault currents generated in the copper tube modified the magnetic field, and one could not assert that the quantity of heat developed in the iron would be the same *after* the copper tube was replaced as it was before. This possible source of error M. Arnoux pointed out could be removed by securing the said iron cylinder to the spindle of the revolving magnet; the cylinder being then stationary relative to the revolving magnet, there would be no generation of the Foucault currents in it. If at the present moment the mechanical equivalent of the calorie was only known accurately to two places of decimals it was, said M. Arnoux, due in a large measure to the fact that its determination had always been carried out by means of diminutive apparatus, mere scientific toys, which only absorbed one or two kilogrammetres per second; apparatus in which losses by radiation attained a high figure. With large apparatus the losses by radiation became negligible, since the volume of the calorimeter increased as the cube and its radiating surface increased only as the square of its linear dimensions. With appliances capable of transforming into heat not merely a few kilogrammetres, but a few hundred kilogrammetres per second, we ought to succeed in determining the mechanical equivalent to three or four places.

ELECTRIC MINING-MACHINERY, WITH SPECIAL REFERENCE TO THE APPLICATION OF ELECTRICITY TO COAL-CUTTING, PUMPING, AND ROCK-DRILLING.*

BY LLEWELYN B. ATKINSON AND CLAUDE W. ATKINSON, ASSOC. MM. INST. C.E.

(Continued from page 560.)

Turning to the application of electricity to movable machinery, the authors have for the last four years been constantly engaged in the design of electric coal-cutting plant, and the results of the work done in this direction will now for the first time be published.

Although this use of electric power has only recently become an accomplished fact, it is interesting to note that the idea presented itself to Mr. Henry Wilde, F.R.S,, of Manchester, one of the earliest pioneers in the development of the dynamo machine, as long ago as 1873, when he described the application of electric power to coal-cutting machines of various forms, in a provisional patent taken out by him in that year.

It was in 1887, so far as the authors know, that the first machine was built for the purpose of cutting coal by electricity. It had a cutter of the bar type revolving on its own axis, a form which it appears was first introduced by Mr. Grafton Jones, and was driven by a motor designed for the purpose, and made by Messrs. W. T. Goolden and Co. The original experiments were conducted at the collieries of Messrs. T. and R. W. Bowers, and the conception of thus employing electricity is due to Mr. F. Mori, electrician, of Leeds, and Mr. J. Blackburn, manager to Messrs. Bowers. Considerable difficulties were, as was natural, found in adapting power to conditions so novel, and so outside all ordinary experience; and, in order to obtain full information as to the obstacles to be overcome, the authors devoted a good deal of time to practically working at the coal-face the various machines that have been constructed. These difficulties have been twofold: namely, electrical and mechanical. The original machine designed by Mr. J. Blackburn was provided with a motor arranged to fit it. This was a three-coil vertical motor, adapted to work in a horizontal position. It was of 6 H.P., and was driven by a dynamo having a normal output of 10 H.P., the motive power being the engine of a hauling-machine, situated at the bottom of the shaft. The distance between the dynamo and the motor was about a mile.

The original dynamo and original motor were both compound-wound, the series-coils on the motor consisting of sufficient turns of thick wire to nearly saturate the magnets with the large current developed on first closing the switch; but when running at a normal load this series-coil had little influence on the magnetisation, which was then affected by the shunt-winding; so that the regulation as to speed was almost as good as if the winding had been simply shunt. This arrangement is convenient as giving a good starting power, and at the same time ensuring satisfactory speed regulation; but in the case of coal-cutting machines the authors have a preference for a series-wound dynamo and series-wound motor, for reasons previously described, namely, that when the motor is being stopped, by the insertion of a proper resistance, the electromotive force may be reduced nearly to zero before breaking the circuit; and further, if it is desired to handle the cables or to disconnect them, or to handle any part of the circuit of the machine after it is stopped, there is no liability to a shock should the insulation at any other point be defective. This is of great importance in a motor intended to be used by inexperienced miners, who are easily frightened, even by a moderate shock, so that they neglect to adjust the brushes, &c., even if they are not so far afraid that they will not work the machine at all. This first plant, which is still working satisfactorily, was, it will be noted, practically unprotected from dirt, dust, or explosive gases, and it was in connection with this that the authors first devised their system of enclosed motors.

With the next machine, built by Messrs. Goolden, as it was desired to cut into the coal at a height which was suitable for using direct driving without the intervention of gearing, the armature-shaft itself was made to carry the cutter-bar. The opinion, however, which the authors now hold is, that although this method of working is quite feasible, it is on the ground of expediency not desirable. It is difficult to construct armatures with shafts large enough to carry the strain put upon them by a cutter bar of the description used without cramping the space for wire and insulation.

Figs. 3 and 4 show still later developments of this class of machinery, in which the cutter-bars are mounted on a separate shaft, and driven by steel double helical gear-wheels. The point to be noted is the combination of the electrical structure with the more strictly mechanical framework, thus providing the greatest amount of strength and electrical power with minimum weight and size. The dimensions of the heading along the coal-face are generally so small that it is only by great compactness that the use of these coal-cutting machines is rendered possible.

Fig. 5 shows in plan the general method of working. The machine, mounted on its wheels standing on the rails laid along the face, is adjusted by means of a turn-table and worm-gear, so that the cutter-bar points along the heading; the current is switched on, and the bar, revolving rapidly on its axis, is turned through an angle of 90° so as to enter the coal. The worm-gear and table being then locked, the machine is drawn along, by means of a winch and wire-rope, cutting its way as it goes. Automatic methods of winding have been devised, but that of pulling in by hand is probably the simplest in the end, and has the advantage of enabling the man at the winch to tell whether the machine is cutting in hard or soft material, and accommodate the rate of movement accordingly. Automatic winding-gear is usually arranged to work at a fixed speed, which must necessarily be that at which the machine will cut in the hardest material to be dealt with, so that with softer material the progress is obviously less than it need be.

The authors have suggested an automatic winding-gear intended to obviate this objection. It consists of a ratchet-and-pawl motion,

* Abstract of Paper read before the Institution of Civil Engineers.

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the pawl being under the control of an electro-magnet. Since the load on the motor is accurately measured by the current flowing through it, the magnet can be so adjusted that if the load should exceed the desired limit the pawl would be lifted out of gear, and the feeding stopped until the machine had eased itself again to its normal load, when the pawl would commence to feed it forward.

All the motors used for these coal-cutting machines are entirely enclosed as to every working part. The field magnets are lagged in steel coverings, the switches, with their resistance frames, are placed in iron boxes, and from the outside it would be difficult to see that the machine was an electric motor. Furthermore, precautions have been taken to thoroughly enclose the gearing, and all bearings and their parts into which grit can obtain access, and the system of lubrication is such that the oil passes from the armature-shaft to the cutter-shaft, and thence is drained into the gear-box, which has an oil-tight joint, so that the gear eventually revolves in oil.

A particular arrangement of machine was shown which was required to cut at any height from 9in. to 33in. from the road-level. This was effected by bolting to one of the pole-pieces a casting with two segmental slots. The cutter-bar was carried in a support moving on these slots, and by these means could be raised and lowered to any height, remaining at the same time in fixed relation to the armature shaft from which it is geared. It is interesting to point out to electrical engineers how the somewhat difficult problem of arranging this machine, so as to avoid the magnetic short-circuiting of the poles, has been met. The leakage from such extended pole-pieces is considerable, but not nearly so excessive as might at first sight be thought.

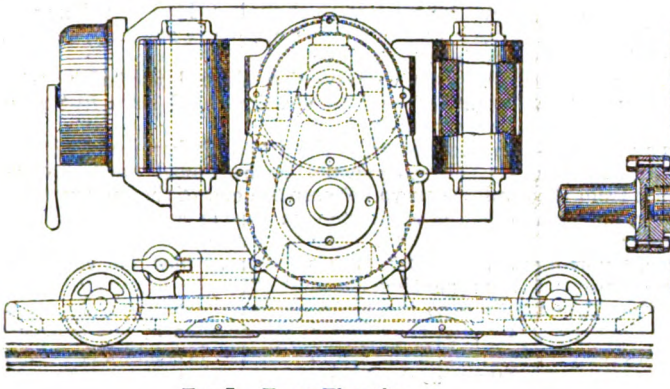

FIG. 3.—Front Elevation.

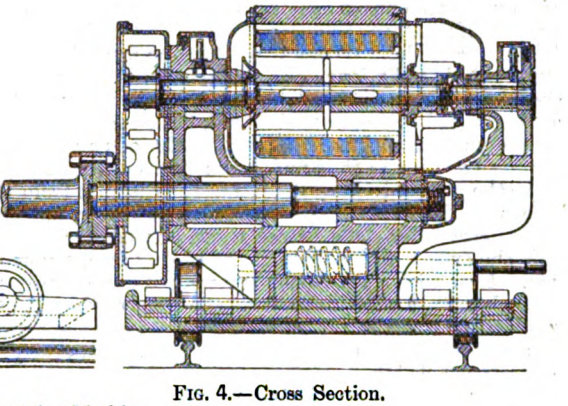

FIG. 4.—Cross Section.

Goolden Coal-cutting Machine.

Several forms of armature have been tried in these machines, with both "drum" and "gramme" windings; and the authors are of opinion that on the whole the "gramme" armatures are best adapted for the work, the reason being that it is very difficult to secure the wire across the ends of a drum-winding in such a manner as to ensure their being positively driven; and in the absence of such positive driving it seems only to be a question of time when the insulation will become abraded by the excessive vibration. One form which has been much used in these machines was illustrated. The armature core is deeply notched to receive the coils, and when these have been wound in place the whole is covered with a layer of annealed charcoal-iron wire. By this means a notched armature, giving a low magnetic resistance in the air-space, is obtained, whilst the production of eddy-currents and consequent heating of the polar horns is avoided, and the armature is of a form which can be handled and laid on the ground, if necessary, without any damage occurring to the wire or its surface.

It soon became evident that the ordinary brushes used on dynamos and fixed motors were useless, owing to the excessive vibration to which the machines were subjected, whilst various forms having butt-contacts, in which the brush was pushed forward by springs, gave rise, both with metallic and with carbon blocks, to excessive heating, due, as far as can be ascertained, partly to the friction on the commutator, and partly to the inferior electrical contact thus obtained.

Brushes of a type which has been successfully used in launch and tramway work, and was originally designed by Mr. Holroyd Smith, composed of blocks of metal carried by light steel fingers or springs, were also tried with similar results, and finally the authors have adopted various forms in which the necessary elasticity is given either in the brush itself, or in a light steel back, there being, however, no movable hinge or knuckle which would allow it to chatter as a whole on the commutator.

The chief mechanical problem in connection with these coal-cutting machines has been: First:—What is the best form of gear to use? and secondly, What is the best form to give to the cutter-bars and cutters? As to the gear, the authors have tried chains of every description and strength, and have had to abandon them all; they have also tried phosphor bronze gearing of ordinary forms, but have finally adopted, as working more smoothly and with less noise, and giving a maximum of strength, cast steel double helical wheels, shrouded nearly to the pitch line. By mounting one of such a pair of wheels in a manner free to slide to a small degree upon its shaft, the perfect alignment of the wheels is secured and the running leaves little to be desired.

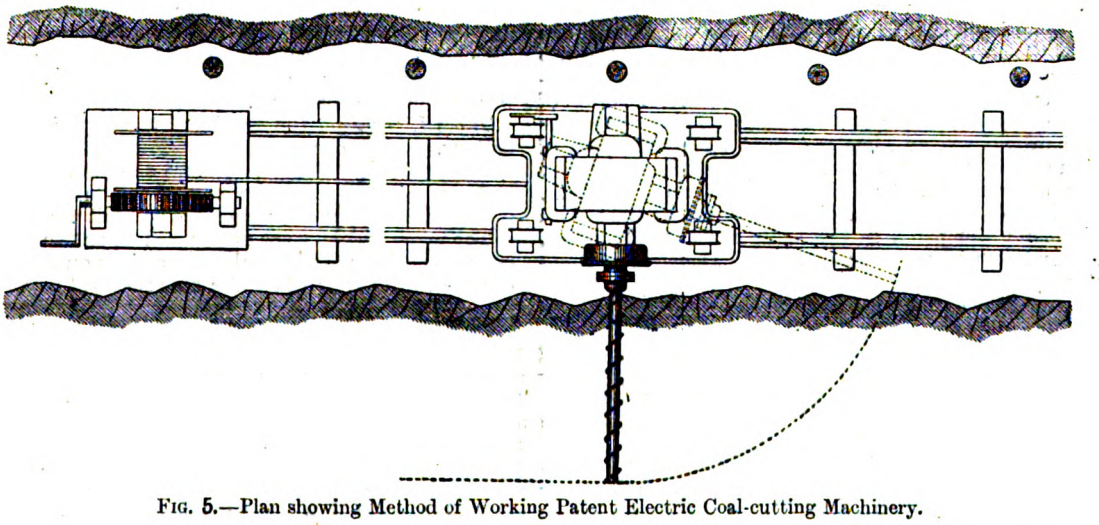

FIG. 5.—Plan showing Method of Working Patent Electric Coal-cutting Machinery.

Although the several machines illustrated in this Paper have been made to cut above the floor level, at heights specially suited to each particular case, so as to work in the bands of shale or dirt and thus save the coal, yet the form with a bar-cutter is eminently suitable for cutting at the level of the floor itself, and the authors have designed machines for this purpose, the rails being laid directly on the surface thus formed. The form of cutter most usually adopted in such cases is that of a large disc or wheel with

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the tools fixed into its periphery. This disc is carried on a bracket projecting from the side of the machine, and is caused to revolve by a pinion gearing into teeth either cut in its horizontal surface, or into teeth formed on its periphery, the teeth of the pinion being then made sufficiently long to allow the tools to cut clear at the bottom. The tools are spread out so as to cut the material clear of the disc.

Machines on this principle have been used with considerable success in several places, but the authors consider the bar cutter is to preferred for several reasons.

First, there is a considerable amount of difficulty in making a machine with a disc cutter to turn round so as to cut its own way under the coal, and in fact in most cases this is done by hand.

Secondly, when the tools are blunt, they have to be taken out and replaced by sharp ones while the disc remains in the coal, a matter of some difficulty in the confined space and with the small amount of light available. With a bar-cutter, on the other hand, since the bar is only held by four bolts at the coupling, it is turned out of the coal and a fresh one with a complete set of new cutters substituted, the other being sent to the bank to be reground.

Thirdly, if the coal or roof is at all tender there is a great tendency for it to fall as soon as it is undercut; to avoid this, wedges are inserted in the groove to keep it up, but the distance from the front of the cut to the back of the disc is considerable, and as a consequence the coal often falls before it can be wedged; this, of course, jambs the cutter, which then has to be dug free, involving a loss of time. Now with a bar-cutter the wedges can be inserted close behind the bar, only a few inches from the front of the cut, and the coal supported, so that even if it falls it cannot jamb the cutter.

Fourthly, a bar-cutter can be made to bare to a greater depth, as much, for instance, as 5ft.

Fifthly, in order to make an electric motor of sufficient power while the weight is kept small, it is necessary to run it at a fairly high speed, and therefore, to keep the gearing compact, the cutter must also run at a high speed. This is easily attained without any disadvantage with a bar cutter, but is quite impossible with a disc cutter, where the speed of the tools would be so great as to seriously heat and soften them. In practice the authors run the motors at about 700 revolutions per minute, while the cutter makes about 500 revolutions per minute. On the other hand, the disc cutters will draw more of the fine coal out of the groove than the bars will; but this advantage is not sufficient, in the authors' opinion, to compensate for the disadvantages enumerated above.

(To be continued.)

TESTS OF THE TUDOR AND CORRENS ACCUMULATORS.*

In response to an invitation issued by the Berliner Electrische Beleuchtungs-Aktiengesellschaft parallel series of tests on the two above accumulators were undertaken by Dr. Heim and Prof. Kohlrausch, of Hanover, Prof. Peukert, of Brunswick, and Dr. Voller, of Hamburg, as theoretical experts; and Messrs. Otto Berner, Gustav Conz, and Richard Seifert, of Hamburg, and Germershausen, of Berlin, as commercial engineers. Dr. Classen, of Hamburg, also assisted at the measurements. The tests took place on the 11th, 12th, 13th, and 14th of July, on batteries laid down by the Berlin Correns Accumulator Company, in the Wilhelmshalle, Hamburg, and by the Hagen Accumulator Company, in the Thalstrasse, Hamburg, respecti vely.

The object aimed at was to submit both batteries to a series of similar tests, under, as far as possible, equivalent conditions. Voltage measurements were accordingly taken with batteries of 50 cells of each kind, which had not recently been put in or out of circuit by the switch, from which it may be concluded that they were under as nearly identical conditions as they can be when in actual work. Further, since the voltages of the cells themselves must exceed those found for a coupled-up battery, the losses occurring in the connections, as determined during charging, were added to the values obtained during the discharge, so as to arrive at the actual voltages of the cells. The instruments belonging to the central stations were not used for measurements of current and voltage, a torsion galvanometer and resistances from the Hamburg City Physical Laboratory, and from the Electrical Institution of the Technical High School at Hanover, being employed instead. The instruments were compared carefully, and the means of several readings were taken.

Tests as to insulation showed no faults which, on account of "earths," or short circuits, could have had any appreciable effect on the results.

With regard to the limits of charge and discharge, it was agreed that charging should be continued until the turning point in the voltage curve between the end of the final rapid rise and the subsequent gradual increase during an overcharge should clearly have been reached. The discharge was to be stopped when the voltage showed a fall of 10 per cent. below the value at which it remains for some time constant after the commencement of the discharge. Since at the close of the discharge the pressure falls off very rapidly, the effect on the amount of the discharge is not very important if the fall in pressure is somewhat greater or less than this 30 per cent. The current was kept constant as far as practicable.

The tests made on the two batteries were as follows:—

(*a*) 1, charge; 2, discharge; 3, charge at a current of about ·5 ampere per square decimetre.

(*b*) 4, discharge at about 1 ampere per square decimetre.

(*c*) 5, charge; 6, discharge; 7, charge at from ·6 to ·7 ampere per square decimetre.

(*d*) 8, discharge; 9, charge; 10, discharge at about 1 ampere per square decimetre.

The Correns Battery.

The Correns battery tested started working at the beginning of May, that is about 2½ months before the time at which the experiments were made. The type was their H_{21} C, 924 ampere-hours capacity, charging current, 154 amperes. The charge thus occupied about 5 hours. Each cell contained 21 negative and 22 positive plates, the total surface of each electrode being 300 square decimetres.

According to the statements of the men in charge, the battery had been regularly charged according to their instructions, and discharge had not been carried lower than to about 1·83 volts per cell. Mr. Correns, a few days previous to the experiments, had had the cells emptied, and had superintended the filling of them with acid. Consequently, during the course of the experiments, the battery, as far as can be the case with one in regular work, was in a normal condition.

Table I. contains the results of the experiments on the Correns battery. The observers were Messrs. Germershausen, Heim, Kohlrausch, and Seifert. Before the first measured charge, the battery was charged at the normal current until gas was copiously given off, and then discharged to the limit arranged upon.

Too much weight must not be laid upon the values for the efficiency found from the several tests, as it is only after a large number of such equivalent tests that a true result at a given current can b$_e$

Table I.

—	No.	Interval in time.	Duration of test in hours.	Average current (amperes).	Current density (amps. per sq. decim.).	Average volts.	Change of volts (in percentage of orig. value).	Ampere hours.	Watt hours.	Efficiency. Reknd. from tests No.	Efficiency. Ampere hours.	Efficiency. Watt hours.	Amp. hrs. in percentage of discharge No. 2.
Charge	1	20 min.	6·30	157·0	0·52	2·191	+ 18·0	990	2,170	1	...	...	...
Discharge ...	2	27 „	6·03	154·7	0·52	1·981	− 9·9	933	1,850	and	97·3	87·5	...
Charge	3	3·2 hrs.	6·00	155·0	0·52	2·215	+ 18·0	930	2,060	3	...	...	...
Discharge ...	4	23 „	2·48	317·0	1·06	1·930	− 10·6	787	1,520	...	...	...	84·4
Charge	5	30 min.	4·78	178·8	0·60	2·236	+ 21·0	856	1,910	...	...	...	...
Discharge ...	6	25 „	4·60	196·7	0·66	1·962	− 9·4	906	1,780	...	...	...	97·1
Charge	7	3 „	4·90	183·4	0·61	2·214	+ 19·0	900	1,990	...	...	...	...
Discharge ...	8	1 hr.	2·63	309·0	1·03	1·935	− 10·0	814	1,570	8	...	...	87·2
Charge	9	1 „	2·70	316·5	1·06	2·276	+ 21·0	856	1,950	and	92·8	78·3	...
Discharge ...	10	3 „	2·43	318·0	1·06	1·935	− 9·5	774	1,500	10	...	...	83·0
Totals ...								Charge 4,532	10,080	...	93·0	81·5	...
								Discharge..... 4,214	8,220	...			

* From the *Elektrotechnisches Echo.*

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Table II.

——	No.	Interval in time.	Duration of test in hours.	Average current (amperes).	Current density (amps. per sq. decim.)	Average volts.	Change of volts(in per-centage of orig. value).	Ampere hours.	Watt hours.	Efficiency. Rckned. from tests No.	Efficiency. Ampere hours.	Efficiency. Watt hours.	Amp. hrs. in percentage of discharge No. 6.
Charge	1	20 min.	5·40	134·3	0·47	2·308	+ 23·0	726	1,670	1 and 3	...	...	...
Discharge ...	2	10 „	4·50	152·7	0·53	1·928	- 9·8	687	1,320		91·6	76·2	102·0
Charge	3	5 hrs.	5·55	139·6	0·48	2·322	+ 23·0	775	1,800		...	...	...
Discharge ...	4	19 „	1·90	319·5	1·11	1·806	- 15·0	607	1,090		...	...	90·3
Charge	5	15 min.	4·37	175·0	0·61	2·394	+ 25·0	766	1,830		...	...	...
Discharge ...	6	13 „	3·45	195·0	0·68	1·909	- 10·3	673	1,280		...	...	...
Charge	7	1·5 hrs	3·83	179·3	0·62	2·338	+ 24·0	687	1,600		...	...	...
Discharge ..	8	6 „	2·00	311·0	1·08	1·816	- 13·9	622	1,130	8 and 10	...	...	92·5
Charge	9	18 min.	2·38	292·0	1·01	2·475	+ 24·0	696	1,720		82·2	65·2	...
Discharge ...	10	20 „	2·00	302·0	1·05	1·847	- 11·7	604	1,110		...	...	89·8
						Totals ... Charge		3,650	8,620	...			
						Totals ... Discharge.....		3,193	5,930	...	87·5	68·8	...

obtained. The full capacity of the battery at the current indicated by the maker's 155 amperes (discharge 2) is given. A current strength 1·3 times as great as this gave 97 per cent., and a current strength twice as great (discharges 4, 8, and 10) gave at the mean 85 per cent. of this capacity.

As the result of all the tests an efficiency of 93 per cent. in ampere hours and 81·5 per cent. in watt hours was obtained. The mean current (reckoned from all the tests) at charging was 1·28 times, and at discharging 1·68 times, those indicated respectively by the makers; the current density during charging averaged ·69 amperes per square decimetre, and during discharge ·9 amperes per square decimetre.

The Tudor Battery.

The Tudor battery had been at work since November, 1890—that is to say, for about eight months, at the time it was tested. The type was No. XX. of the price list for April, 1889. Capacity, 660 ampere hours; charging current, 165 amperes; discharging current, 198 amperes, and so made for charging in three hours. Each cell contained 16 negative and 15 positive plates, the total surface of each electrode being 288 square decimetres. According to the men who had been running the battery, it had been up to six or seven weeks before the tests fully charged or overcharged. During these six or seven weeks, however, the charge had, without exception, been too small. More exact information could not be obtained, as no books were forthcoming; but it may be considered probable that during this time the Tudor battery had only received too small charges, and that, consequently, it was not quite in a normal condition. The battery was not overhauled by the contractors previously to the tests. Unfortunately, the Accumulator Company refused to take any part in the tests. Table II. contains the results of the tests on the Tudor battery. The observers were Messrs. Berner, Conz, Peukert, and Voller.

Before the first measured charge the battery was charged at normal current until gas was freely given off, and then discharged down to the arranged limit.

The figures clearly show that the behaviour of the battery improved during the tests. This is evident from the fact that in Tests 6 and 7, and particularly in the three last tests at about 300 amperes, the capacity and the efficiency in ampere hours come out strikingly high in comparison with the three first tests at about 150 amperes. These results are, thefore, in accordance with the statements of the attendants, since, if the Tudor battery during the six or seven weeks preceding the tests had not been fully charged, its action, which had deteriorated owing to the small charges, would naturally have improved during the complete charges and discharges it was subjected to during the tests.

As mentioned above, no great weight must be attached to the values found for the efficiency from the several tests. The full capacity of the battery at the current indicated by the makers, 195 amperes (discharge 6), is given. A current strength 1·6 times as great as this (discharges 4, 8, and 10) gave on an average 91 per cent. of this capacity.

As the result of all the tests, efficiencies of 87·5 per cent. in ampere hours and 68·8 per cent. in watt-hours were obtained. The mean current from all the tests in charging was 1·12 times, and in discharging 1·29 times those indicated respectively by the makers. The current during charging averaged ·61 amperes per square decimetre, and during discharge ·85 amperes per square decimetre.

The above results do not allow any conclusion to be drawn with regard to the superiority of either kind of accumulator in reference to efficiency or the relation between capacity and current strength, nor could the question have been settled if the Tudor accumulator had been regularly charged before the tests were made. Such a general conclusion could only be drawn after tests on a large number of batteries of both kinds. The tests also would have had to be more exact and more complete than those now made. It may also be remarked that the circumstance that the Correns battery is constructed for a five-hour discharge, whilst the Tudor completely discharges in three, could hardly be taken into consideration.

The results actually obtained prove that the particular Correns battery tested considerably surpasses the particular Tudor battery tested as regards efficiency both in ampere hours and watt hours. The Correns battery showed efficiencies which have never yet been surpassed by any kind of accumulator.

No tests were made as to the influence of over charging or over discharging. Obviously, moreover, no conclusion can be drawn as to the lives of the two accumulators.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *September* 15, 1891.

The Montreal Meeting of the National Electric Light Association.—The meeting of the National Electric Light Association at Montreal may be counted as a grand success. The Convention was remarkably well attended, and something like 200 delegates had assembled as early as Sunday night, September 6th. A special train came through from New York bearing more than a hundred people, and was joined at Rutland, Vermont, by a special train from Boston bearing fifty more. The headquarters of the Association were at the Windsor Hotel, where the accommodations were for such a gathering of the very best. The citizens of Montreal had made most elaborate preparations for the thorough entertainment of their visitors, and there was a constant round of entertainments of one sort or another all the time the Convention was in session. The business meetings were held in the morning, and the afternoon was given up to miscellaneous work and entertainments. The exhibition of electrical machinery and appliances held in the Victoria Rink, closely adjoining the headquarters, was probably the finest ever held in the country. There have been more pretentious exhibits partaking of a spectacular nature, but nothing anything like so complete a collection of working machinery. Of course, the Thomson-Houston and Edison companies were in the front rank of exhibitors; in fact, to a certain extent, the Convention was made the field of a tolerably sharp cross-fire between these two great rivals, and a vigorous effort was made in certain quarters to utilise the National Electric Light Association for pulling Edison chestnuts out of the fire. This inner history in the political economy of the Convention, however, did not appear in any disagreeable way, and produced no serious result on the Convention as a whole, although the existence of such an undercurrent was quite obvious. The Westinghouse Company was conspicuous by its absence.

Power for the use of the exhibitors was kindly furnished from the dynamo room of McGill University; the Edison Company receiving it on a gigantic railway dynamo used as a motor, and the Thomson-Houston Company on a similar large machine. One of the most interesting exhibits was that of Mr. H. Ward Leonard, who, as I have before mentioned, recently severed his connection with the Edison Company, like

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so many others of the well-known electrical engineers of this country. Mr. Leonard showed a new device of his invention for regulating motors, the fundamental idea being to run a given motor at any desired speed and any necessary torque, the velocity of rotation being independent of the load. The motor employed was operating an electric hoist, and picked up its load at any desired speed within a very wide range and was under the most perfect control; the suspended weight could be brought down with great rapidity to a point close to where it was to be placed, and then lowered far more gently than could be accomplished by any other means, or its motion reversed if necessary. It was something unique among motors of any sort in its extremely perfect regulation, retaining meanwhile a surprisingly high efficiency. Its only inconvenience was that it required a control of both the motor and the generator, so that in case of deriving the power from a central station it becomes necessary to transform by a generator on the spot, as was done in this particular instance, the current operating an Edison motor being used to drive a dynamo, which in turn was used to drive a dynamo to supply the working motor. Another exhibit that attracted a great deal of attention was the Thomson-Houston reciprocating rock drill, shown in actual operation gnawing its way into a block of stone.

During the Convention, the Governor-General of Canada was a visitor at the Exhibition, and was present at the banquet given by the citizens of Montreal on Friday evening, September 10th.

The Papers read at the Convention were of a high order of merit. Perhaps the most important work accomplished was the formulation, by the Committee on Safe Wiring, of a set of standard wiring rules, to supersede the diverse regulations now enforced by the insurance companies. The committee that was appointed for the purpose of working up this Report contained two practical insurance inspectors, and with their co-operation a set of provisional regulations of a very complete and valuable character was drawn up and presented to the Association. A permanent committee to take charge of the matter was appointed; and at the next Convention the rules, with slight modifications, will doubtless be adopted. Other valuable Papers were those by Mr. Jas. J. Ayer, Mr. C. J. Field, and Captain Eugene Griffin. The discussions contained much that was of interest, but were less vigorous than at any preceding Convention.

Too much cannot be said for the hearty welcome given the Association by the citizens of Montreal, who extended every possible courtesy, and gave to their friends from the States as warm a reception as could have been desired. The members of the Association will carry away with them the warmest regard for their Canadian hosts, and most pleasant memories of an unusually successful and agreeable Convention.

SCANDINAVIAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

COPENHAGEN, *September* 21, 1891.

The Copenhagen Telephone Company intend to introduce several facilities for its subscribers from the beginning of next year. Night service will be introduced at the Copenhagen head station, and the Company offers cheaper rates for connections in the interior of the town.

The principal square of Copenhagen, the "Kongens Nytorv," a large and handsome square, will probably soon be lighted by electricity; whether electric lighting will be adopted for other public places or streets remains to be seen.

The laying down of the State telephone cables in Stockholm has now been going on for some time. The so-called American system is adopted. The cables are placed in blocks of cast cement, each block calculated for 36, 18, or 15 cables, as the requirements of the locality may be. These blocks are firmly attached to each other by the Hultman patent method, and are laid in connected lengths of 120 metres. At every 120 metres there is a manhole, serving the double purpose of hauling in and connecting house wires. Each cable contains enough wires for 100 subscribers. The getting of the cables through the ducts in the cement blocks has in some places caused some trouble, and various devices have been tried, among which may be mentioned the one used in America of employing rats, a plan which was, however, soon abandoned. In Stockholm it is proposed to fasten together a number of one-metre wooden rods by iron hooks, and then to push these through from manhole to manhole. In order to facilitate the passage of the cable and reduce the friction the ducts will be greased with a mixture of vaseline and paraffin.

CORRESPONDENCE.

THE CORRECTION FOR "g" IN CONNECTION WITH SIR WILLIAM THOMSON'S STANDARD BALANCE INSTRUMENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR,—In your issue of the 18th inst. you say "Sir William Thomson appears to have overlooked the correction for 'g' in connection with his Standard Balance instruments." As a matter of fact this has not been done. The current on these instruments varies as the square root of the weight used; and consequently, though the variation of "g" between Glasgow and London is about $\frac{1}{25}$ per cent., the error so introduced into the indications of a standard electric balance would be only $\frac{1}{50}$ per cent., while the error introduced into an instrument removed from Glasgow to the Equator would be $\frac{1}{7}$, if no correction were made. A correction is, however, made whenever a standard is being sent from Glasgow to a place where the difference in "g" would produce any appreciable error. The amount of this correction is determined by data from tables of variation for "g", and when no data are available for the particular place, "g" is calculated from the well-known formula

$$g = G\,(1 + \cdot00513 \sin^2 \lambda).$$

(See Thomson and Tait's "Elements of Natural Philosophy," § 187.)

Where G is the apparent force of gravity upon unit mass at the Equator, and λ is the latitude of the place.—I am, &c.,

Physical Laboratory, ANDREW W. MEIKLE.
The University, Glasgow, Sept. 23, 1891.

THE DETERMINATION OF CURRENTS IN ABSOLUTE ELECTRO-MAGNETIC MEASURE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the excellent series of Papers by Mr. Searle now appearing in *The Electrician*, he refers to the well-known theorem "$\Sigma F \alpha = 4\pi \times$ (quantity of north magnetism inside)" as due to Prof. Stokes. The fact is, the theorem is due to Gauss, who published it in 1839. His Paper containing it was translated, and appeared in "Taylor's Scientific Memoirs," Vol. III., pp. 153-196. It is the theorem of section 22 of that Paper. In 1849 Prof. Stokes published a Paper on Clairaut's theorem in the "Cambridge and Dublin Mathematical Journal," Vol. IV., pp. 194-219. For convenience he collected a number of "propositions respecting attractions," of which proposition VII. is the one above referred to. In a footnote to p. 195 Prof. Stokes says, "not one of the 'propositions respecting attractions' is new, although now and then the demonstrations may differ from what have hitherto been given. With one or two exceptions, these propositions will all be found in a paper by Gauss, of which a translation is published in the third volume of 'Taylor's Scientific Memoirs,' p. 153. The demonstrations here given of propositions VI. and VII. are the same as Gauss's."

Trusting that you may regard the above correction as deserving of insertion,—I am, Sir, &c.,

J. D. HAMILTON DICKSON.

Peterhouse, Cambridge, September 22, 1891.

SMOKE ANNIHILATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The system alluded to in your issue of September 18th, under the above heading, of supplying hot air behind the bridge of the furnace to assist the complete combustion of the fuel, though old, is a good one, judging by its extensive use; but it is difficult to understand how it can account for the

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analysis of the fuel and results as quoted by you from the *Chemical Trade Journal*. The analysis of the fuel used gave 28·35 per cent. of volatile matters, chiefly hydrocarbons; and that of the flue gases gave 100 per cent. of nitrogen, oxygen, and carbon oxides, but *hydrogen absent* in all forms; while it goes on to state "that economy is effected by thus obtaining more perfect combustion, this is proved by the fact that the hydro-carbons, usually allowed to escape unburnt, contain three-tenths of the heat of the original fuel."

It would be interesting if the Gaseous and Liquid Fuel Supply Company would explain how their tests can be reconciled with the laws of the conservation of energy, for, with the system employed the hydrogen cannot have "gone off in smoke."—I am, Sir, &c., W. GEIPEL.

TRADE NOTES AND NOTICES.

TENDERS WANTED.—The Common Council of Pisa announce that they are prepared to receive tenders for the supply and distribution of electricity for public purposes within the city. Further particulars may be obtained from Signor A. Nardi-Dei, dal Palazzo Comunale, Pisa, to whom tenders are to be sent by December 15th.

——— The Town Council of the Borough of Eastbourne are prepared to receive tenders for a "Westminster chiming clock" for the Town Hall, to be fitted for illumination with all the necessary appliances. Further particulars may be obtained on application at the Borough Surveyor's Office, Town Hall, Eastbourne. Tenders supplying full particulars must be sent to Mr. H. West Fovargue, Town Clerk, Town Hall, Eastbourne, on or before October 13, 1891. Further information will be found in our advertisement columns.

——— The Taunton Town Council desire tenders for the supply and erection of electrical fire calls within the borough. Plans, specifications, and other information may be obtained at the office of the Water Works Manager, Municipal-buildings, Taunton, and tenders are to reach Mr. T. Meyler, Town Clerk, by October 5.

MESSRS. BENHAM AND FROUD'S NEW CATALOGUES.—Messrs. Benham and Froud (Limited) have forwarded us advance copies of their new catalogues of electric-light fittings and wrought-iron work. The former contains some very handsome examples of the manufactures for which this firm are justly celebrated; every design in the book is original, and the whole of the work has been made at the factory in Chandos-street, Strand, London, W.C. Included in the designs shown are electroliers, brackets, ceiling lights, church fittings, floor and table lamps, pillars, glass and silk shades, standards, lanterns, pendants, &c. Some of the designs are especially handsome, and suitable for use in the most artistic installations of the electric light. All are carefully marked and priced, and Messrs. Benham and Froud notify that specimens of most of the fittings shown can be seen in their show rooms. The catalogue of wrought-iron work, although containing no specimens of electric-light fitting work, is full of new and original designs, many of which could be readily adapted to the electric light if required.

MESSRS. BALDERSTON AND CO.—We have received from this firm a little treatise on machine-belting, issued by Messrs. Fayerweather and Co., of New York, for whom Messrs. Balderston and Co. are agents for the United Kingdom.

MR. WILSON HARTNELL.—We are informed by Mr. Farrar, the London agent for Mr. Wilson Hartnell, of Leeds, that he has secured the order for the electric lighting of the new flour mills for Messrs. James Tucker (Limited), Cardiff, which, when complete, will rank amongst the largest in the country.

SUNBEAM LAMPS.—The Sunbeam Lamp Company send us a price list of their lamps, which are made in sizes varying from 150 c.p. to 2,000 c.p., and are suited for pressures from 50 to 110 volts. They are made in two classes, the one for high efficiency, and the other for longer duration. There is an undoubted saving in first cost by using these lamps instead of groups of small lamps. The efficiency of the first class appears, by the figures given in the price list, to be 2 watts per candle, and the second class 2½ watts per candle. These probably refer to the initial candle-power when new. No information is given as to falling off of candle-power or life. These factors will not, we believe, allow them to compete with arc lamps, and it is difficult to estimate the economy compared with small lamps.

RANSOMES, SIMS, AND JEFFERIES.—This firm sends us a new catalogue and price list of their steam engines, boilers, and other machinery. They illustrate among their boilers a multitubular externally fired cylindrical boiler, requiring a limited space for setting.

PHOTO COPIES OF TRACINGS.—Messrs. Bemrose and Sons, of 23, Old Bailey, E.C., send us specimens and a price list of their papers for white line, black line, and blue line prints; together with particulars of printing frames, dishes, and other accessories.

WOODHOUSE AND RAWSON UNITED (LIMITED).—This firm have opened a branch office and sample room at 89, Bothwell-street, Glasgow, which is under the management of Mr. B. F. Howard, who has been appointed agent for Scotland.

THE CRYSTAL PALACE AND DISTRICT ELECTRIC LIGHTING.—We learn that Messrs. J. E. H. Gordon and Co., of 11, Pall-mall, who have secured the order for the central station and mains for the supply of electricity to the Crystal Palace Exhibition, and afterwards to the Sydenham district, are making rapid progress with their works, and will have their station of 20,000 lights capacity in full work on the opening of the Exhibition on January 1st next.

ELMORE COPPER.—The Elmore Patent Copper Depositing Company send us facsimile copies of fourteen testimonials as to the excellence of their copper tubes. We are requested by the Secretary to notice these testimonials, "as statements have occasionally appeared raising the question as to whether the process can be relied upon to produce uniformly good articles at a reasonable price." We have never questioned the quality of these goods, but have doubted whether the advantages would be so great, and the price so low, as the promoters have loudly proclaimed. We are glad to learn that, at all events, fourteen firms—apparently customers—are satisfied as to quality.

NEW COMPANIES, STATUTORY RETURNS, &c.

BROWN'S ENGINE COMPANY (LIMITED).—This Company has been registered in Scotland, with a capital of £15,000 in £5 shares. Object:—To adopt and carry out an agreement with Mr. Alexander Francis Gordon Brown, Swindridgemuir Dalry, and William David Russell, of Maulside, Ayrshire, to acquire the invention for an expansion rotary engine, described in letters patent of February 2, 1888, and also the patents therefor in Great Britain, Austria, Belgium, Germany, France, Italy, Spain, and the Spanish Colonies, New South Wales, Queensland, South Australia, Victoria, New Zealand, India, Canada, the United States of America, and Brazil; to take out patents, British, foreign, or colonial, for the invention; to acquire other inventions and work these; and to carry on the business of engineers, mechanical engineers, machine and engineering tool makers, boiler makers, ironfounders, brass founders, millwrights, metal workers, and steel converters; and to buy, sell, manufacture, repair, convert, let on hire, and deal in engines, machinery, rolling stock, metals, metal implements tools, and utensils of all kinds. The office of the Company is in Glasgow.

PARTINGTON CYCLE COMPANY (LIMITED).—This Company was registered on September 19, 1891, with a capital of £10,000 in £1 shares, by S. S. Seal, 7, Serjeants' Inn, Temple. The objects are:—To carry on the business of mechanical and electrical engineers, machinists, cycle manufacturers, and all or any of the businesses connected therewith. Office, Mill-street, Middleton, Lancaster.

J. CAWTHRA AND COMPANY, LIMITED (Manufacturers, Merchants, Suppliers of Electricity, Gas, &c.).—The statutory return of this Company, made up to July 7, 1891, was filed on July 13th. The nominal capital is £120,000 in £10 shares, all of which are taken up, and £107,450 paid in respect of calls, while the remaining £12,550 is considered as paid. Office, 7, Swaine-street, Bradford.

COLLIER AUDIBLE TELEPHONE SYNDICATE (LIMITED).—The statutory return of this Syndicate, made up to September 1, 1891, was filed on the 7th following. The nominal capital is £9,000, in £100 shares, all of which are taken up. The full amount has been called upon 30 of the shares, and £2,860 paid, leaving £140 unpaid 60 shares (of which 30 belong to A. T. Collier, of 38, Gray's Inn-road, W.C., and 30 to the London and Colonial Finance Corporation (Limited), are considered as fully paid. Office, 5A, Coleman-street, E.C.

CUTTRISS, WALLIS, AND COMPANY (LIMITED).—An agreement made April 20, 1891, between T. Cuttriss and S. W. Cuttriss (trading as Cuttriss and Co., of the first part, E. C. Wallis of the second part, and R. W, Graham (on behalf of the above Company), of the third part, states that the Company intend to take over the business of Cuttriss and Co., of the Elmwood Electrical Works, Leeds, and also that of E. C. Wallis, electrician, of 1, Bond-place, Leeds; and in full satisfaction for the said businesses 420 fully paid-up shares will be allotted to the vendors or their nominees, which shares, however, will not rank for dividend during the first year unless 10 per cent. is paid on the paid-up capital. S. W. Cuttriss and E. C. Wallis are appointed Managing Directors for five years, from November 1, 1890. Remuneration for such services will be at the rate of £150 per annum each, for the first two years, and £200 per annum each for the remainder, and in addition the sum of £25 per annum for each £1 per cent. over 6 per cent., provided that the additional remuneration do not exceed £150 per annum each. The statutory return, made up to August 14, 1891, was filed on the following day. The Company, which was registered on April 22, 1891, has a capital of £10,000, in £5 shares, 736 of which have been taken up. Upon 316 shares £3 per share has been called, and with the exception of £10 paid, while the remaining 420 have been considered as fully paid. Office, Elmwood Electrical Works, Camp-road, Leeds.

FROUDE-HURRELL TORPEDO COMPANY (LIMITED).—The statutory return of this Company, made up to Aug. 14, 1891, was filed on the 21st following. The Company, which was registered on the 24th March last, has a capital of £10,000 in £10 shares; 121 of the shares have been taken up, the full amount called, and £760 paid, leaving the remaining £450 unpaid. Office: 3, Broad-street Buildings, London, E.C.

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WEYBRIDGE ELECTRIC SUPPLY COMPANY (LIMITED)—The statutory return of this Company, made up to August 8th, was filed on September 3, 1891. The Company was incorporated to take over the Electric Lighting Depôt, Weybridge, carried on by the Laing, Wharton, and Down Construction Syndicate (Limited), and had a nominal capital of £15,000 in £5 shares; seven shares have been taken up, but no calls have been made, and the present shareholders are the original subscribers. No agreement for the taking over of the business has as yet been filed. Office: Thames-street, Weybridge.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the past week were £4,849.

CITY AND SOUTH LONDON RAILWAY COMPANY.—The traffic receipts of this Company for the past week amounted to £684.

CITY OF LONDON ELECTRIC LIGHTING (PIONEER) COMPANY (LIMITED).—Notice is given that the transfer books and register of members of this Company was finally closed on the 18th inst.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company announces the payment, on October 15th next, of interest of 3s. per share, less income-tax, being at the rate of 6 per cent. per annum, on the preference shares of the Company for the quarter ended September 30th, and the usual interim dividend of 2s. 6d. per share on the ordinary shares, free of income-tax, in respect of profits for the quarter ended June 30th. The register of transfers will be closed from Oct. 7th to 14th, both days inclusive.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—The Directors have declared an interim dividend for the quarter ended June 30th last of 2s. 6d. per share, payable on the 15th prox.

GLOBE TELEGRAPH AND TRUST COMPANY.—The Directors of this Company have declared an interim dividend of 2s. per share.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended September 18th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,780.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The receipts of this Company for the two weeks ended September 15th show a decrease of £591 as compared with the corresponding period last year.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Sept. 16.		Price Wednesday, Sept. 23.		Rate per Cent. Yielded.	Dividend Due.	Business done during Week ending Sept. 23.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS.								
£1,300,980	Stock	12/0	Anglo-American	48½	49½	48	49	5 12 3	Jan., Apr., July, Oct.	49½	48½
£2,849,510	Stock	24/0	Do. Preferred	87	88	86	87	6 4 1	" "	88	86¾
£2,849,510	Stock	5/0	Do. Deferred	13¾	14¼	13½	13¾	..	.. ..	14¼	13½
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99	102	99	102	3 18 5	January and July ..	100½	..
130,000	£10	5/0	Brazilian Submarine	11¾	12½	11¾	12½	6 18 9	Mar., June, Oct., Dec.	12½	11½
£69,200	£100	5%	Do. 5 per Cent. Bonds	99	102	99	102	4 18 0	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103	107	103	107	4 13 6	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	117	119	120	123	5 9 9	April and October ..	122½	119
16,000	10	8/0	Cuba Submarine	10	11	10½	11½	6 19 2	February and August	..	..
6,000	10	10%	Do. Preference 10%	16½	17½	17	18	5 11 1	" "	..	..
12,931	5	3/2½	Direct Spanish (£4 paid)	3½	4	3½	4	7 0 0	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9½	10½	9½	10½	4 15 3	" "	..	..
60,710	20	3/6	Direct United States	10¾	11¼	10¾	11¼	6 5 10	Jan., Apr., July, Oct.	11¼	10¾
400,000	10	5/6	Eastern	14¼	14½	14¼	14½	4 10 5	" "	14½	14¼
70,000	10	6%	Do. 6 per Cent. Preference	15	15½	15	15½	3 17 5	" "	15½	15
£1,200,000	Stock	6%	Do. 4 per Cent. Mort. Debenture Stock	107	110	107	110	3 12 9	May and November	108½	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 10 11	February & August	..	..
250,000	10	2/6	Eastern Extension	14¾	15¼	14¾	15¼	4 12 7	Jan., Apr., July, Oct.	15¼	14¾
£330,000	£100	4%	Do. 4 per Cent. Debenture Stock	105	108	106	109	3 13 5	February & August	107½	107
£85,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	104	107	104	107	4 13 6	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	102	105	102	105	4 15 3	" "	..	..
180,227	10	4/6	Globe Telegraph and Trust	9⅝	9¾	9⅝	9¾	5 6 4	Jan., Apr., July, Oct.	9 13/16	9 7/16
180,042	10	6%	Do. 6 per Cent. Preference	14¾	15¼	14¾	15¼	3 19 4	" "	15 7/16	14 13/16
150,000	10	5/0	Great Northern	18¾	19¼	18¾	19¼	4 8 4	Jan., April, and July	19⅛	19
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	104	107	104	107	4 13 6	March & September	..	..
17,000	25	37/6	Indo-European	41	43	41	43	5 15 3	May and November	42½	42
38,848	10	5/0	London Platino-Brazilian	6¾	7⅛	6¾	7⅛	6 0 0	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	104	107	104	107	5 12 2	March & September	106½	..
9,000	8	4/0	Reuter's	8	8½	8	8½	4 14 1	April and October..	8⅝	..
3,381	£100 Cert.	£1	Submarine Cables Trust 6%	120	125	120	125	4 16 0	" "	..	..
15,609	10	6/0	West African Telegraph	8	9	8	9	5 11 1	January and July ..	8	..
£231,400	100	5%	Do. 5 per Cent. Debentures	96	99	96	99	5 1 0	March & September	98	..
30,000	10	2/0	West Coast of America	3¾	4	3¾	4¼	..	January and July ..	..	..
£150,000	100	8%	Do. Debentures 8% 1902	97	102	98	103	7 15 4	June and December	..	..
88,321	10	9d.	West India and Panama	1⅜	2	1⅜	1⅞	..	..	1⅜	..
34,568	10	6%	Do. 6 per Cent. 1st Preference	9¾	10½	9½	10	6 0 0	May and November	..	..
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8	9	8	9	6 13 4	" "	..	..
61,683	15	9/0	Western and Brazilian	10¾	11½	10¾	11½	6 13 4	" "	11½	10¾
30,364	7½	1/6	Do 5 per Cent. Cumulative Preferred	6¾	7	6¾	7	5 7 3	—	..	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	4¾	5	4¾	5	..	..	4¾	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	102	105	102	105	5 14 9	February & August	104½	103½
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	102	105	102	105	5 14 3	" "	104½	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117	122	117	122	5 14 9	May and November	..	..
£178,100	£100	6%	Do, per Cent. Sterling Bonds	98	102	98	102	5 17 8	March & September	..	..
			TELEPHONES.								
234,850	14/0	0/5½	Consolidated Telephone Const. & Maintenance	1/16	1/8	1/16	1/8	..	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid)	1/16	1/8	1/16	1/8	6 3 11	Yearly	..	..
488,984	5	3/6	National	4½	4¾	4½	4¾	6 13 4	June and December	4¾	4 7/16
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½	13½	12½	13	4 12 4	" "	12¾	..
15,000	10	6%	Do 6 per Cent. Cumulative 2nd Pref. (£8 pd)	12½	13	12½	13	3 14 1	" "	..	..
350,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd)	106	108	105	107	4 4 1	..	107½	106½
58,000	5	1/0	United River Plate	2⅛	3⅛	2	3	..	January and July ..	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 8	—	..	..
			ELECTRICITY SUPPLY COMPANIES.								
1,000	£10	..	City of London Electric Lighting (£4 paid, £10 8h.)	4	4½	4	4½	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	4½	5	..	..	..	..	..	..
5,322	£5	..	House to House Electric	4½	5	4⅜	5⅛	..	..	..	..
30,000	£5	..	Liverpool Electric Supply (£3 paid)	2⅛	2⅜	4⅛	5⅛	..	..	..	..
111,000	5	..	London Electric Supply	1⅛	1⅜	2⅜	2⅝	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	9¾	10⅛	10	10⅜	..	..	10 1/16	10¼
7,730	£5	3/6	St. James' and Pall Mall	8	8⅜	7⅜	8⅛	..	..	8¼	7⅜
..	..	7%	Do. 7% Preference	4½	5	4⅜	5⅛	..	..	5 1/16	4⅞
42,853	5	..	Westminster Electric Supply (£5 paid)	5½	6	5⅜	6⅛	..	..	6¼	5⅞
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
77,978		6%	Brush Electrical Engineering	2⅜	3⅛	3⅛	3⅜	5 6 8	..	3⅜	3⅛
69,996		6%	Do. 6 per Cent. Preference	1⅜	2⅛	1⅜	2⅛	5 12 11	June and December	2⅛	1⅜
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	4½	5⅛	5	5⅛	6 7 3	January and July ..	5	..
17,130	5	..	Edison and Swan United	..	..	..	..	..	—	..	..
45,000	10	6%	Electric Construction	4½	5	5⅜	6⅛	..	—	5⅜	5
70,000	2	10/0	Elmore's Patent Copper Depositing	4¼	4½	3¾	4	..	—	4⅛	3¾
20,000	5	..	Fowler-Waring Cables (£4 paid)	2	3	2	3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	19½	20½	20	21	4 15 3	February & August	20⅜	20 1/16
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	104	106	104	106	4 4 11	March & September	..	..
11,334	£10	6/4	International Okonite Limited Ordinary	7⅛	8⅛	7⅛	8⅛	11 15 3	..	..	..
11,334	£10	5/0	Do. Preference	9½	9¾	9½	9¾	8 4 1	..	..	..
78,949	5	2/1½	Swan United (£3. 10s. paid)	4¾	5¼	5	5⅛	6 7 5	May and November	5⅛	5
37,350	12	12/0	Telegraph Construction and Maintenance	42	44	42	44	5 9 3	March and July.....	43½	43
50,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	102	105	102	105	4 15 3	January and July ..	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£2. 10s. paid)	2½	2⅝	2½	2⅝	..	..	..	..
—	£5	..	Do. Preference (fully paid)	3¾	4	3¾	4	—	..	..	..
			RAILWAYS.								
50,000	£10	..	City and South London Railway	3	5	2	4	—	—	—	—

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THE ELECTRICIAN:

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NOTES.

In many respects it is to be regretted that there is nothing in this country to correspond with the National Electric Light Association of the United States. The members represent the class which attend, or ought to attend, the meetings of the London Chamber of Commerce; in the holiday aspect of the Convention it resembles the British Association; and for carefully prepared papers and practical discussions it may be compared with our Engineering Institutions. The papers are limited in number, they are printed beforehand, and in the hands of the members, and they are of a solid and representative character. Some of the topics, such as arc-light supply and street railways, do not at present largely concern us on this side of the Atlantic; but they were dealt with in a practical way, which must have been appreciated by the American audience. The zone system advocated by the President is open to the criticism that if it be admitted that distribution at high electrical pressure is satisfactory and advisable, it may as well be used for the centre of the town as well as for the outlying districts.

It is easy to see the advantage of throwing out high-pressure feeders to the suburbs of a town, while no such feeders are required for the streets neighbouring on the supply station. But to use two systems concurrently, to say nothing of the multiplication of different voltages for different distances, reminds us of the hole which Sir Isaac Newton made in his door for the kitten, alongside the one provided for the cat.

Fortunately for us in this country we know little of the tyranny of parent companies over supply companies, and it is difficult to realise the serious complaints which are made against them by the supply companies in the United States. This appears to be an outcome of the American "electric light systems." An Edison Supply Company uses everything of the Edison brand, and a station fitted by the Brush Company has not a single article in common with the Edison. Our American friends seem to suffer particularly in the measuring instruments thus supplied to them.

The remarks which were made at the meeting of the National Electric Light Association about measuring instruments ought to encourage our manufacturers to brave the McKinley tariff, and show what can be done in the way of ammeters and voltmeters for station work. We would call attention to the observations of Dr Louis Bell, which will be found in our abstract of the fifth day's proceedings, and recommend those of our readers who are specially interested in the matter to read the remarks of Mr. Ayer and of Mr. Scott, in the full report which appears in the *Electrical World* of New York for September 19th. We need not go so far as Montreal to hear grumbling about the accuracy of instruments. Prof. Kennedy, in the discussion on Mr. Crompton's Paper before the Institution of Civil Engineers, said that he had been scoffed at because he wanted a voltmeter to be right to a volt, and was told that he should not expect it. This sounds rather like the "parent company" tyranny. We hope that before long we shall have reports of the work done by the Electrical Standardising Laboratory, giving details, like the Kew report, of the accuracy attained and the number of instruments examined. Such information is much needed by instrument makers who really try to turn out good work. We shall not be surprised to learn that voltmeters may be purchased for five pounds which will read to a quarter of a volt.

In our leading article of March 20th we discussed the alleged decrease of hysteresis in the iron core of a transformer under heavy loads. To be more accurate, we did not discuss the question itself, but the way in which it had been handled. The position was very disappointing. Mr. Mordey, by a method of doubtful accuracy, had detected it, and Prof. Ayrton confirmed it, but without giving any clue whatever to an explanation. We felt confident that either an explanation or a refutation would soon turn up; but six months have elapsed, and the electrical world has since then been busy with Dr. Fleming's explanation of the Deptford phenomena (if this expression is better than Ferranti effect), with Electrical Standards, with Faraday centenaries, and with multiphase motors, and the matter has been almost forgotten. We had secretly hoped that the explanation would sooner or later be found in the course of articles on Magnetism by Prof. Ewing, which are now drawing to a close; and this week we have the pleasure of pointing it out on page 602, section 181, of the present issue.

The explanation of the decrease of hysteresis with heavy load is as simple as the molecular theory of Prof. Ewing, and is "one of those things which anybody could have thought of." Of course, we are quite ready to hear of all the previous publications, and are prepared to learn that it is a very old story, and all that; but of one thing we are quite certain, that no explanation of such complete simplicity has been offered before. Prof. Ewing treats the secondary of the

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loaded transformer, not as a conductor carrying a larger current than at other times, but merely as one which has less resistance than when lightly loaded. Most of our readers are familiar with old alternate current dynamos which took more power to run them idle than when loaded; and this has been explained, with more or less lucidity, as being due to the wasteful production of eddy currents in the one case, and the useful expenditure of the same currents in the external circuit in the other case. Prof. EWING simply shows that the magnetic molecules, instead of vibrating independently and thus setting up eddy currents, have their vibrations damped by the conductor of low resistance, and tend to move in unison, so that such currents as are produced, do not occur in the iron, but in the secondary circuit itself.

PROF. EWING'S explanation will doubtless be criticised. Shall we call it a hypothesis for the present, until the fact of the decrease of hysteresis is firmly established? The swinging molecules, or clots of molecules, having a mass incomparably small in relation to the mass of the magnet, may be supposed to spread their own lines of force in their own neighbourhood; and these, under ordinary conditions of hysteresis, are considered to set up eddy currents, also in their own neighbourhood; that is, in the body of the iron. But, on the other hand, it may be argued that since the resultant lines of force are merely due to the combined effect of all the constituent molecules, we must look for a swinging of the whole resultant field. But this supposes a homogeneity of field; and the question then arises, is the field in the interior of a magnet practically homogeneous, or do the molecules or small aggregations of them, in behaving according to Prof. EWING'S hypothesis, redistribute the lines of force in their own neighbourhood, and can we consider their lines of force apart from the resultant lines of force of the magnet as a whole? It appears that the small local vibrations are held to account for ordinary hysteresis; but that when this alleged decrease is dealt with, the resultant external field is considered. We do not for a moment suppose that Prof. EWING is blowing hot and cold in this way; but as the difficulty referred to may occur to others, we hope he will give us further information on the subject.

A RATHER more complete proof is still wanting that this decrease actually exists, but it is not worth the while of engineers to spend time on the investigation. They could easily spare a little more power on well-loaded transformers; it is the extravagance of the idle ones that is offering so serious an obstacle to the progress of electric lighting by transformers. We hope to publish in an early issue a description of the very simple apparatus which Prof. EWING has employed in investigating this matter.

WE publish this week an article by M. PELLISSIER, in which he offers a simple explanation of the action of the Wimshurst machine. The theory of the influence machine has not kept pace with the development of the apparatus itself, for the explanations given in text books are much more applicable to the older than to the newer types of machine, and are especially unsatisfactory in accounting theoretically for the great practical improvement which has taken place. The parts of the machine forming the collectors figure prominently in the usual theory, as in the older class of machine, such as Thomson's replenisher, they were an important part of the whole. In recent machines, however, the collectors are a minor detail, just like the brushes of a dynamo, and M. PELLISSIER points out that, as the Wimshurst machine will fully charge itself without the aid of collecting combs, the theory of its action must be independent of them, and may be simplified by supposing them removed. The theory of M. PELLISSIER is very similar to that given by Prof. THOMPSON in his classical Paper on the "Influence Machine," read in 1888 before the Institution of Electrical Engineers. The matter is, however, put in a novel way, and the steady increase of charge is explained very satisfactorily. As the author points out, the explanation of the self-excitation of these machines is still obscure. It is generally put down to residual electric charge on the plates, just as dynamos are supposed to excite owing to residual magnetism in the field. It must, however, be borne in mind that the polarity of each sector in a Wimshurst machine in action is constantly reversing, so that residual effects can hardly be expected.

A SATISFACTORY method for determining alternate-current curves is much needed, and in many ways this want seems supplied in the apparatus referred to in another column, the details of which will be found described by M. BLONDEL in a recent number of *La Lumière Electrique*. The best research hitherto in connection with these curves is due to Prof. RYAN, an account of whose apparatus will be found in *The Electrician* for January 10th of last year. The success of this work was, however, largely dependent on the use of a new kind of electrometer. M. BLONDEL'S method requires no new instrument, and although the contact breaker is very elaborate, the curves can be very quickly obtained when the apparatus is once set up; and the method has the great advantage that the current and potential curves can be obtained simultaneously, and permanently recorded by means of photography. Nearly all the methods yet devised for finding these curves need some modification of the contact breaker originally used by JOUBERT, and their usefulness must greatly depend on the way in which this portion of the apparatus stands wear and tear. Apparently the new method is satisfactory in this respect, as it is asserted that the contact pieces have been used for an average of three hours a day for a month without serious deterioration.

WIDESPREAD sympathy has been shown for Sir JAMES ANDERSON in the bereavement which he has sustained by the death of Lady ANDERSON on September 25th, after a very short illness.

Esslingen.—We learn from the *Elektrotechnische Zeitschrift* that the Maschinenfabrik Esslingen proposes to erect a central station for the supply of light and power in that town.

The Old Students' Association.—The annual dinner of the O. S. A. has been postponed until Saturday, October 31st. It will then be held at the Holborn Restaurant at seven o'clock, and tickets may by obtained from the secretary or any member of the committee.

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Odessa.—The lighting of the Harbour of Odessa for the Russian Government, which has been carried out by the Hamburg branch of the Thomson-Houston International Electric Company, is now in full work. The installation includes 64 arc lamps and 8 incandescents.

Spherical Harmonics.—Several correspondents have asked us where Prof. Perry's Table of Zonal Spherical Harmonics is published. We are informed by the author that it will probably be found, together with a few examples of its use, in the forthcoming October number of the "Philosophical Magazine."

Liverpool Electrical Engineer.—The Liverpool Corporation have received 93 applications for the position of electrical engineer. The Committee unanimously appointed Mr. J. C. Sherman to the vacant post. He has had a training under Prof. Lodge, and has for the last three months been engaged in working for the Corporation.

"The Times" and the Frankfort Exhibition.—The "leading journal" may generally be looked to for early, complete, and original news; but the whole of the account of the Frankfort Exhibition, which appeared in its columns "From a Correspondent at Frankfort" on Monday, the 28th, is to be found verbatim "By the Editor" in a contemporary of September 25th.

Proposed Lighting of the Sheerness Naval Barracks.—The Admiralty have under consideration proposals for lighting Sheerness Royal Naval Barracks with the electric light. An estimate has been forwarded of the cost, together with estimates of the expense of several other improvements in the establishment, which is about to be converted into a school of gunnery.

A Compressed Air Power Supply for Lucerne.—The electrical power plant in use at Lucerne having been found insufficient to meet the demands for small powers, amounting to about 1,440 H.P., it has been decided to erect a plant on the compressed air system, and the contract has been given to Messrs. Riedinger of Augsburg, which firm carried out the work in connection with the compressed air plant at Offenbach. It is expected that the Lucerne plant will be in working order within two years.

Train Lighting.—One of the express trains running between Berlin and Frankfort has been fitted with the electric light. Each coach has two distinct storage batteries, and the lamps are on two distinct circuits, so that in case of accident to one circuit, or on changing the batteries, the carriage shall not be left entirely without light. The storage cells are especially designed to stand rough handling, and have a capacity of 200 ampere-hours. Each battery supplies current to four 8 c.p. lamps for the compartments and to one 5 c.p. lamp in the lavatory. The batteries, which weigh 6 cwt. each, are placed in boxes underneath the carriage floor, and can be taken out and replaced very rapidly.

Heriot-Watt College.—The new session of this College commences on Tuesday, October 6th. Last session Mr. William G. Rennee, a student of the College, obtained one of the four Whitworth Scholarships annually offered for competition throughout the United Kingdom, and of the value of £125 per annum, tenable for three years. Also in the Technological Examinations of the City and Guilds of London Institute, 5 prizes, 8 medals, and 80 certificates were awarded to the students of the College, including the third prize and medal in Electric Lighting and Transformer of Power awarded to Mr. John Henderson. Particulars of the Engineering Classes will be found in our advertisement columns.

Berlin.—We learn from the *Volkszeitung* that a detailed project for the erection of a system of electric railways in Berlin has been laid before the municipal authorities by Messrs. Siemens and Halske. According to this firm elevated roads form the only feasible method of providing means of rapid transit. The first line which it is proposed to take in hand is the South or Canal line, extending from the Zoological Gardens along the Landwehr Kanal and the Skalitzerstrasse to the Oberbaumbrucke and the Warschauerstrasse terminus of the City Railway. Should this line, which would have a length of 8·9 km., prove successful, seven other lines in connection with it, having a total length of 40 kms., would be proceeded with.

St. John's Church, Newcastle.—This church has been supplied with electric light, which was used for the first time on the occasion of the harvest festival on the 24th ult. There are 22 lamps fixed, each of 100 candle-power. They are so arranged that sections of them can be shut off separately from the others, so that the light can be reduced at any time, as, for instance, during the sermon. The lamps hang from the apex of each arch. There are six lights in the chancel, which are arranged so that two, four, or the whole number can be used, as the case demands. The most pleasing feature was the great improvement obtained by the removal of the heavy gas pendants from the central aisle. The current is supplied by the Newcastle and District Electric Lighting Company.

The Phonopore.—This remarkable telegraphic system is coming into practical use on several lines in this country. One of the Great Northern Railway Company's lines from King's Cross to Retford is fitted with it, and on the Midland Railway a duplexed passenger line between St. Pancras Station and Derby is arranged with a phonopore connection for the goods service; between the goods stations some 250 messages a day have been sent over it for the last two months. On the Great Western Railway a phonopore set is provided on a line between Paddington and Exeter, there being five single-needle intermediate stations which work independently of the phonopore. The mechanical adjustments of the instrument have been modified, and it has now assumed a thoroughly practical form.

Obituary.—We regret to record the death at Greenwich, on September 26th, at the age of 46, of Mr. Thomas John Brown, the Chief Electrician of the Telegraph Construction and Maintenance Company, in succession to the late Mr. Joseph May. Mr. Brown entered the service of the Telegraph Construction Company in 1864, having previously been engaged with Messrs. Glass, Elliott and Co. He had been occupied on all the important Atlantic cable expeditions, and also in the laying of many of the Eastern, Eastern Extension, and Brazilian Company's cables, his last expedition having been on the triplicate Aden-Bombay section early in the present year. Mr. Brown was esteemed a faithful servant by the Telegraph Construction and Maintenance Company, and his loss will be sincerely regretted by a wide circle of friends. We regret to record the death at Vienna on September 26th, of Mr. John Douglas Lyle Gibbs, after a protracted illness. Mr. Gibbs was for many years the Eastern Telegraph Company's manager in Egypt, and has since represented that Company at Vienna.

Interruptions and Repairs to Telegraphic Lines.—

	Date of interruption.		Communication restored.
	1891.		1891.
Ceara-Pernambuco Cable	Mar. 14	.....	Sept. 12
St. Jaques-Thuan An-Haiphong Cables	June 28	.....	*
Transandine Line	Aug. 19	.....	Sept. 4
„ „	Sept. 13	.....	„ 14
Shanghai-Amoy Cable	Aug. 22	.....	„ 3
Valparaiso-Santiago Line	„ 29	.....	„ 2
Saigon-Bangkok Line	„ 30	.....	Aug. 30
„ „	Sept. 1	.....	Sept. 2
„ „	„ 4	.....	„ 5
„ „	„ 9	.....	„ 11
„ „	„ 18	.....	not yet restored.
Foochow-Shanghai Cable	„ 2	.....	
Communication with—			
Guatemala *vid* La Libertad	„ 9	.....	Sept. 12
„ „ „	„ 15	.....	„ 16
Moulmein-Bangkok Line	„ 10	.....	„ 11
Siberian Lines	„ 10	.....	„ 11
„	„ 16	.....	„ 16

* Not restored, messages sent by land line at same rates.

The Junior Engineering Society.—The tenth annual general meeting of this flourishing society was held last Friday evening at the Westminster Palace Hotel, Victoria-street, Westminster. Mr. W. J. Tennant, Grad.Inst.P.A., occupying the chair as usual. A highly satisfactory report for the past session was read by the Secretary, Mr. Walter T. Dunn, showing an increase in membership of 34 per cent. In consideration of the long cherished project for publishing the proceedings of the Society, and possibly opening a reading-room and museum of its own, it was moved from the chair that the subscription of members over 21 years of age be increased; after a long animated discussion this motion was carried. Officers for the ensuing session

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were elected. Mr. Tennant having held the post of chairman for so long, withdrew his name from the list of nominations for the position, in case he should be re-elected. Mr. S. Boulding was elected in Mr. Tennant's place. An attractive programme of excursions and other arrangements is in course of preparation for the eleventh session. It is interesting to note that this Society, founded ten years ago by half-a-dozen young engineers, has now over 260 members of all classes enrolled.

Production of Copper in the United States.—A special bulletin, issued from the Census Office, states that since the Census year 1880, the United States has risen to the rank of the largest copper producer in the world, outstripping by far any other country. During the decade Arizona and, later, Montana have become important producing States, the latter now acquiring and maintaining its rank as leader. While by far the greater part of the metal produced is obtained from ores in which lead, gold, and silver are the principal constituents of value, these quantities are difficult to trace to their source. The ores are purchased by lead and copper smelters in the open market, often in small parcels, indirectly through sampling works. Sometimes copper is not even present in the original ore in marketable quantity, and becomes a factor only when it appears in a concentrated form in the matters of lead smelters and refiners. The copper product of the United States was as follows, in pounds, in the calendar year 1889 :—

Arizona	31,586,185
Michigan	87,455,675
Montana	98,222,444
New Mexico	3,686,137
Colorado	1,170,053
Idaho, Nevada, Utah, California, Wyoming, and Vermont	571,882
Southern States	18,144
Lead smelters and refiners	3,345,442
Total	226,055,962

Statistics of Lightning in Germany.—Lightning casualty returns have been made in conformity with a German Ministerial Order, showing the extent to which the buildings belonging to or under subsidy from the State have, within the period from 1877 to 1886, been damaged by lightning. The number of buildings with regard to which returns were collected was 53,502, of which 22,682 were actual State property, and 30,820 were entitled to State subsidy for rebuilding or repair. Buildings were struck in 264 cases, or about five for every 1,000 buildings in ten years. Of the various classes of buildings the number struck per 1,000 for the period are as follows :—Elementary schools, 0·8 ; parochial houses, 1·4 ; revenue buildings, 1·7 ; prisons and penitentiaries, 3·4 ; forest-rangers' houses, 7·2 ; churches, 8·2 ; court-houses, 11·9 ; seminaries, 14·6 ; gymnasia, 15·4 ; university buildings, 24·1 ; domain buildings, 44·9 ; and horse-breeding establishments, 312·5. Those which are the property of the State are less subject to injury by lightning than those only under subsidy. Out of the 264 cases in which the lightning struck, eighty-one, or not even one-third, resulted in a fire. The amount of injury wrought by lightning on the 53,502 houses coming within the scope of these statistics was £56,834, or £215 for each casualty, or 21s. per building in ten years, about 2s. per building per annum. The amount of injury done to domain and horse-breeding establishments was considerable, amounting to £42,000, or more than two-thirds of the total injury caused by lightning. It has been calculated, from the returns of sixty fire insurance companies of Germany, Austria, and Switzerland, embracing the period from 1855 to 1877, that the danger from lightning has increased two and a-half fold in those countries, during the period named. The danger is said to have increased three-fold in Germany within the last thirty years. The average loss sustained annually by Germany from this cause is computed at from six to eight millions of marks. Casualties have thus increased in the period of lightning conductor extension.

Underground Telegraph Wires in China.—The *Electrical Engineer* of New York is responsible for the following :—"A superstitious reverence for the dead accomplished years ago in China something that regard for the comfort and safety of the living, even when aided by judicial mandates and radical municipal methods, has been only partially able to accomplish in this country," said a telegraph lineman who was in the employ of the company that established the first telegraph line in China. "The telegraph wires are placed underground there, and if the company had not so disposed of them there would have been no telegraph lines in China to this day. Dead ancestors are held in peculiar reverence in that curious country, and the casting of a shadow upon the grave of an ancestor is looked upon by the Chinese as an insult not to be borne, and it is always resented with impetuous rage. Now there are no cemeteries or general burying grounds in China, but every family's ancestors, particularly in the rural districts, are buried on the family premises. Consequently, every yard or garden is a receptacle of ancestral remains, and, as China is thickly populated, the revered bones of dead and gone Mongolian progenitors may be found resting beneath every few rods of earth. When the telegraph company went to work to put up the poles on which to hang its wires the workmen were embarrassed every little while by wrathful Chinamen, who would rush angrily upon certain poles and chop them to the ground, and warn the workmen with much furious chatter that they would put them up again at their peril. The cause of this interference was unknown to the workmen, who were at last forced to discontinue the work, and explanation was demanded by the authorities. Then it was learned that the poles that were cut down had cast a shadow some time during the day on the graves of revered ancestors of Chinamen, and the insult could be wiped out in no other way but by summarily removing the poles. It was found that this superstition was too sacred a one among the Chinese to be overcome by persuasion or bribery, and at last the telegraph company, as a matter of economy and self protection, laid their wires beneath the surface, where they have been ever since."

An Obstacle to our Foreign Trade.—It will be remembered that recent Consular reports from Italy and Japan have referred to the loss of trade owing to firms in England sending to those countries circulars and price lists based on the English weights and measures. The metric system is used in those countries, and our French, German, and other competitors use it in their quotations ; but the English firms are content to puzzle buyers with weights and measures which are very troublesome and not understood. A similar complaint now reaches us from Egypt, and the Consular report just issued (annual series of Foreign Office Reports, No. 944,) points out that our weights and measures are "utterly unintelligible" to a large proportion of the persons to whom export houses in this country forward their circulars and price lists in Alexandria and Cairo. The metric system of weights and measures is in force in Egypt, and exporters of English goods to that country should, of course, adopt it in their quotations and transactions. Not to do so is indeed suicidal shortsightedness, and it is to be hoped that the day is not far distant when the metric system of weights and measures will be generally adopted in England. If this needful reform is not soon undertaken there is little doubt that our foreign competitors will get a hold of our customers abroad which it will not be easy to shake off. In Australia it has been suggested that the adoption of the metric weights and measures should be carried out as one of the early labours of the coming Commonwealth Government of Federated Australia. In the *Sydney Morning Herald* of July 11th last there is the following forcible reference to the subject :—"The fact that such an absurdity as our present monetary system and that of our weights and measures should have survived so long shows how strongly they must have entrenched themselves in the stupidity of human nature. It is a shame to our intelligence that such a burden should have been tolerated so long, and the advance of Australia into the field of nations should be made the occasion of throwing off an incubus that we and our fathers have groaned under so long. It is the business of the colonies to lead old Mother England by her apron strings, as we have often done before ; and there is not much likelihood of her refusing to follow us in a reform like this, that sooner or later will be imperatively demanded by the advance of the intelligence of the age." The foregoing matter has been sent us by the Secretary of the Decimal Association, and we insert it at his request, without assuming any responsibility for opinions advanced.

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MAGNETISM IN IRON AND OTHER METALS.*—LII.

BY PROF. J. A. EWING, F.R.S

(*Continued from page 586.*)

§ 178. **Retentiveness of Nickel.**—A reference to the curves which were given for nickel when the effects of stress were discussed in earlier articles of this series (§§121-122, Figs. 95, 96, 98, and 99,) will show that the presence of longitudinal *push* has a highly favourable effect on the retentiveness of that metal, and on the maximum of residual magnetisation. Pull, on the other hand, is extremely unfavourable to the retentiveness of nickel. A comparison of the results set forth in Figs. 98 and 99 shows that the value of $\frac{d\,\mathsf{I}_r}{d\,\mathsf{I}}$, which is at no stage great in unstressed nickel, rises to a maximum approaching unity when the metal is tested under the influence of strong longitudinal push. And it is, at least, highly probable that the same thing occurs in the steep stage of the magnetising process in the tests under torsion figured in Figs. 120 and 121, § 141.

§ 179. **Amount of Retentiveness possible under the Molecular Theory.**—The full bearing of these experimental results on the molecular theory is not easily traced, and it would be scarcely profitable to speculate at present on the forms in which the groups of molecular magnets may conceivably be arranged. It is, however, important to notice that the theory leaves ample room for even the high retentiveness which iron is found to possess. To show that this is so we may consider what would be the saturation value of the residual magnetism if the structure consisted of lines like those of Fig. 145, with the centres of the molecules grouped in cubical order. It would be unreasonable to postulate any particular directional relation between the lines of centres and the direction in which the piece is to be magnetised. We shall suppose that the structure is an aggregate of tribes of molecules, with a cubical formation for each tribe, but with all possible variety in the direction of the lines of centres.† In the piece as a whole the directions of the lines of centre may be taken as uniformly distributed; in other words, they might be represented by all possible radii of a sphere, drawn so that the points in which they meet the spherical surface are equally spaced.

Suppose that a very strong magnetising force H is applied, so that saturation is produced, and that the force is removed. We have to consider how much residual magnetism will be found when the molecules have returned into lines in which they are stable, and which are as favourably directed for giving residual magnetism as the assumed structure of the substance will permit.

Let α be the angle at which any line of molecules is inclined to the direction of H, before the process of magnetisation begins. Since the distribution of direction is by assumption uniform, the number of molecules whose inclinations are less than α will be to the whole number in the proportion which that part of a spherical surface cut off by a cone of semi-angle α (with its vertex at the centre), bears to the whole spherical surface. In the same way the number of molecules whose inclinations lie between α_1 and α_2 will be proportional to the area of the belt of the sphere's surface, which is cut off between cones with α_1 and α_2 for semi-angle. Let the whole number of molecular magnets per unit of volume be n. Then the number whose inclinations lie between α_1 and α_2 will be

$$\frac{n}{2}\int_{\alpha_1}^{\alpha_2} \sin\alpha\, d\alpha.$$

Let θ be the inclination of a molecule after it has been displaced by the application and removal of H. If m is the moment of a single molecule, it contributes $m\cos\theta$ to the residual magnetism. The whole amount of residual magnetism contributed by those molecules whose original direction ranged from α_2 to α_1, will therefore be

$$\frac{mn}{2}\int_{\alpha_1}^{\alpha_2} \sin\alpha\cos\theta\, d\alpha.$$

And to find the whole residual magnetism we have to extend the limits of this integration to include all the initial directions from $\alpha = 0$ to $\alpha = 180$ deg.

We have next to consider the relation of θ, the inclination after H has been applied and removed, to the original inclination α. Our assumption as to the structure makes the permanent deflection of the molecule necessarily either 0, or 90 deg., or 180 deg.

(1) Molecules for which α is less than 45 deg. will suffer no permanent deflection. This is because the original lines are more favourably directed than lines at right angles to them. For these molecules $\theta = \alpha$.

(2) Molecules for which α is greater than 45 deg. and less than 135 deg. will be permanently turned through one right angle. For these molecules $\theta = \alpha - 90$ deg., and $\cos\theta = \sin\alpha$.

(3) Molecules for which α is greater than 135 deg. will be permanently turned through two right angles. For these $\theta = \alpha - 180$ deg.

The whole residual magnetism, therefore, consists of the sum of three terms, namely

$$\frac{mn}{2}\int_0^{\frac{\pi}{4}} \sin\alpha\cos\alpha\, d\alpha + \frac{mn}{2}\int_{\frac{\pi}{4}}^{\frac{3\pi}{4}} \sin^2\alpha\, d\alpha + \int_{\frac{3\pi}{4}}^{\pi} \sin\alpha\cos(\alpha - 180°)\, d\alpha.$$

The first and third terms are of equal value. The integral of the first term is

$$\frac{mn}{2}\left[\frac{\cos 2\alpha}{4}\right]_0^{\frac{\pi}{4}} = \frac{mn}{2}\times\frac{1}{4}.$$

The integral of the second term is

$$\frac{mn}{2}\left[\frac{\alpha - \sin\alpha\cos\alpha}{2}\right]_{\frac{\pi}{4}}^{\frac{3\pi}{4}} = \frac{mn}{2}\left(\frac{\pi}{4} + \frac{1}{2}\right).$$

The whole residual magnetism is therefore

$$\frac{mn}{2}\left(2\times\frac{1}{4} + \frac{\pi}{4} + \frac{1}{2}\right) = \frac{mn}{2}\left(1 + \frac{\pi}{4}\right) = 0\,8927\; mn.$$

This is the residual magnetism of saturation, and is to be compared with the induced magnetism of saturation, which is mn.

Assigning to mn the value 1,700 this calculation shows that a continuous structure of the kind postulated, cubical in arrangement, is competent, on the molecular theory, to have nearly 1,500 units of residual magnetism, an amount considerably greater than experiments show even the most retentive iron to be capable of holding. It is clear, therefore, that intermolecular magnetic forces are abundantly sufficient to account for residual magnetism, and that the actual structure of soft iron, and still more that of hard iron, steel, nickel, and cobalt, is less favourable to retentiveness than is the simple structure we have been discussing here.

§ 180. **Hysteresis and the Dissipation of Energy.**—The molecular theory shows that hysteresis is to be expected whenever the magnetism of iron is caused to alter through anything more than a very narrow range. It occurs when the molecular movements are sufficiently great to involve the breaking up of old ties, and the formation of new ones, on the part of some, at least, of the molecules. In other words, the necessary and sufficient condition for hysteresis is that there must be an unstable phase in the movement of some of the molecules. The changes of magnetism will then lag behind the exciting cause of the change, whatever that may be.

When the change is restricted within very narrow limits there is no hysteresis, for the molecular movements are then of the quasi-elastic type, occurring without rupture of the molecular ties. A very weak magnetic force, applied and removed (whether acting alone or superposed on a steady force), or a very small change of mechanical strain, will, if it be many times repeated, cause small changes of magnetism which do not involve hysteresis, because the molecular magnets are then suffering deflections with respect to which they are stable. But when

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† The structure may be continuous; in other words, the transition from one direction in the line of centres to another may occur through very slight distortion of the cubical formation.

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the action is extended by using larger magnetic forces or larger variations of mechanical strain, so that the molecules are deflected far enough to become unstable, hysteresis comes into play. We find it, in fact, manifesting itself in all save the narrowest cycles of magnetising force, of longitudinal pull, of torsional strain, and so on.

The dissipation of energy which has been shown to accompany hysteresis in cyclic variations of magnetism is an obvious outcome of the mechanically irreversible character of these unstable molecular movements. When the molecule's equilibrium is upset it tumbles over, and acquires kinetic energy in falling towards a new position of equilibrium. It oscillates about that, and communicates oscillations to its neighbours, until the motion is damped out by setting up eddy currents in the surrounding conducting mass, and the energy of these currents is in turn converted into heat. The damping effect of eddy currents in the surrounding medium may even be so great that there is no continued oscillation; the molecule may be as it were let down gently like a body connected to a dash-pot. In any case, the ultimate effect is that a magnetic cycle generates heat in the substance of the metal. We have seen already that when the cycle is produced by reversing the magnetising force H, this heat is the equivalent of the quantity $\int I\,dH$, and numerical values of it have been given in earlier chapters.

But what will be the heating effect when a magnetic cycle is performed, not by varying the amount of H but by turning the iron round in a constant magnetic field? The question is of much practical interest, since that is the way that the magnetism is reversed in the core of a dynamo armature of the Gramme ring or the drum type. Experiments to answer it are as yet wanting. It appears to have been often taken for granted that the same amount of work is spent in the two cases, but there is no apparent basis for the assumption. In a series of experiments on dynamo armatures by Mr. Mordey*, when a successful attempt was made to separate the loss of power due to magnetic hysteresis for that due to Foucault currents, the loss due to hysteresis was found to be rather less than the amount of energy which would be used up in reversing the magnetism by varying the field without rotation.

The molecular theory makes it probable that the work spent in reversing magnetism will be less when the reversal is accomplished by rotation in a constant field, than when it is accomplished by reducing the magnetic force to zero, and restoring it with sign reversed. A difference of this kind is especially to be looked for when the field is strong. In fields of no more than moderate strength, the turning round of the iron will involve breaking of molecular ties, with those unstable movements to which the dissipation of energy is due. But when the field is very strong so that the iron is nearly saturated, every molecule points steadily in the direction of the magnetising force all the while, and there is no opportunity for irreversible movements. This deduction from the molecular theory seems to have been first pointed out by Mr. Swinburne. The matter is well worth experimental examination.

§ 181. Dissipation of Energy through Hysteresis in the Cores of Transformers.—This is another practical case of magnetic reversals on which the molecular theory seems to have an important bearing. In a transformer, the presence of the secondary coil has of course no influence on the amount of energy dissipated in reversals of the core's magnetism, so long as the secondary circuit is open. But when the secondary circuit is closed, especially through a low resistance, it assists in damping the unstable swings of the molecules, and a part of the energy goes into it which would otherwise be wasted in heating the iron. It appears probable that the damping action of the secondary coil will tend to establish a *régime* in which the molecular magnets swing with some approach to unison, crowds of them keeping step and so to a great extent giving up energy to the secondary circuit, instead of wasting it in local eddies within the iron. This consideration leads us to expect that the waste through hysteresis in a transformer will be less when the load is heavy than when it is light, possibly much less. Experiments on the efficiency of transformers under various amounts of load have in fact led Mr. Mordey and Prof. Ayrton to conclude that this is the case. This subject, like the one referred to in the last paragraph, calls for a fuller examination than it has yet received.

§ 182. Reduction of Hysteresis by Vibration, &c., and other Disturbances.—We have seen (§§ 84, 85, 129) that mechanical vibration lessens the differences of magnetic conditions that are brought about by hysteresis. It makes the metal readier to respond to any influence which tends to alter the magnetism. In a soft iron wire, where its effects are most conspicuous, it practically abolishes the distinction between what we have called the first and second stage of the magnetising process, it destroys the retentiveness almost entirely, and it makes the magnetic effects of strain nearly reversible, so that the "on" and "off" curves for a cycle of loading come to be not far from coincident.

The molecular theory makes all this intelligible. Vibration, producing small periodical displacements of the molecular centres, sets the molecular magnets oscillating. The displacement of the centres, and still more, perhaps, the oscillation to which that gives rise, allows the molecules intervals of comparative freedom, and probably even goes so far as to vary the combinations in which they are grouped. Then if there is an external field the molecules yield readily to it in their freer intervals, and even when there is no external field a kind of shuffling goes on, one effect of which is to reduce residual magnetism. It may be, that in the removal of residual magnetism vibration acts in the first place locally; a cluster of molecules shaken up so that the residual magnetism of the cluster is less than that of surrounding portions will act to some extent like a cavity in the metal, producing a demagnetising field round about it. In the same way the demagnetisation of a long iron rod under vibration no doubt begins at and about the ends, where there is a self-demagnetising field, and then extends itself towards the central portion.

Any kind of disturbance that will give the molecular magnets intervals of freedom, or of diminished constraint, will tend to do away with hysteresis. Interesting examples of this will be found in a Paper by G. G. Gerosa and G. Finzi* in which experiments are described showing how cycles of reversal of magnetism become modified when a continuous, or periodically interrupted, or alternating current is made to traverse the piece under test, while slow reversal of the field goes on. The experiments dealt with iron, steel, and nickel wire in their annealed and hard state. A continuous current, traversing the wire while its longitudinal magnetism was being changed by applying and varying a longitudinal magnetic force by means of a surrounding solenoid, was found, as might be expected, to reduce the susceptibility of iron: the circular magnetisation maintained by the current in the wire left the molecules less than their usual freedom to obey the longitudinal force. When the longitudinal current, instead of being continuous, was rapidly interrupted without changing its sign, a molecular oscillation was set up which made the iron more than usually susceptible to weak longitudinal force; but when the field was strengthened the iron was still found to be less susceptible than when no current was passing through it. The mere make and break of the longitudinal current would, in fact, cause no more than a small variation of circular magnetisation, and would consequently do little to agitate the molecules. But when a rapidly alternating current of moderate strength traversed the wire, its susceptibility was notably increased; the magnetisation curve in that case lies above the normal curve everywhere except in the region of strongest magnetisation. The violent agitation brought about by rapid reversals of circular magnetism destroyed nearly all trace of hysteresis, and obliterated the usual distinctions between sucessive stages in the magnetising process. An illustration is given in Table XXXII. and Fig. 152, which relate to an experiment in which a piece of soft iron wire, 0·84mm. in diameter, was magnetised, first under the usual conditions (without any longitudinal current), and then when traversed by a rapidly alternating current of three amperes.

* "Alternate-Current Working." *Jour.* Inst. Elec. Eng., Vol. XVIII., 889.

* Rendiconti del R. Istituto Lombardo. Vol. XXIV., fasc. x., April, 1891. *See* also a Paper by Dr. Finzi in *The Electrician*, April 3, 1891, p. 672.

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Table XXXII.—*Magnetisation of Iron with and without an alternating longitudinal current.*

Without current.		With current.	
H	I	H	I
1·43	50	0·17	75
2·24	119	0·82	290
3·62	367	4·33	803
5·76	773	12·3	1,178
12·5	1,162	42	1,537
42	1,500	0	76
0	1,121		

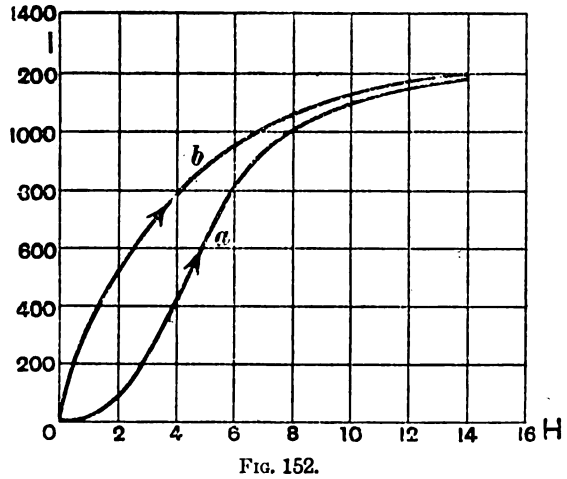

Fig. 152.

In Fig. 152 the curve *a* is the normal curve, and *b* is the curve obtained when the alternating current was in action. The table shows how little residual magnetism is left in the second case.

Fig. 153 exhibits in the same way the influence of the alternating longitudinal current on a cycle in which the longitudinal magnetism of another iron wire was reversed. The normal figure *a a* collapses, as an effect of the molecular shaking, into *b b*, which is very nearly a single curve.

Effects of the same kind were observed in steel and in hard iron, but the suppression of hysteresis was less complete.

The single curve by which the relation of I to H may be represented when hysteresis is done away with by sufficiently violent agitation of the molecules, may be expressed, with fair accuracy, by the formula

$$I = \frac{\alpha H}{1 + \beta H},$$

in which α and β are constants for a given specimen. This formula, which was proposed by Fröhlich as a general means of expressing the relation of magnetism to field, is, of course, of

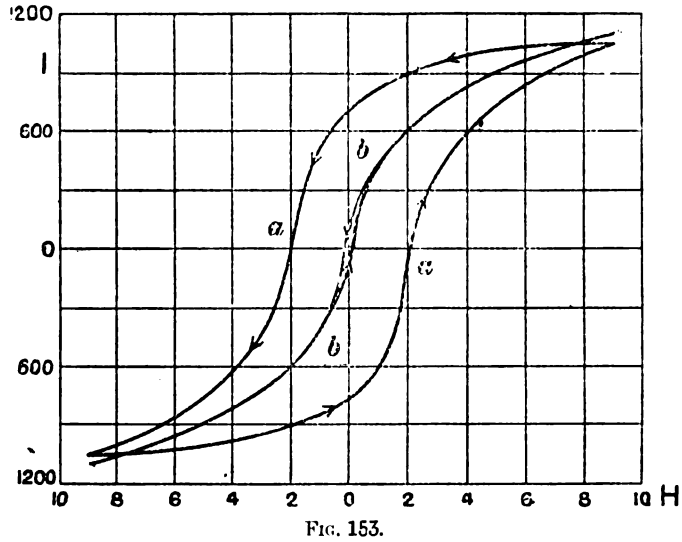

Fig. 153.

no service so long as hysteresis is operative, since I then depends not only on the existing value of H but on previous values: it will not even serve to express the curve of initial magnetisation in a virgin piece. But when hysteresis is eliminated, as in these experiments, it may be made to fit the curve reasonably well. Values of the constants α and β will be found in the Paper from which these results are quoted.

(To be continued.)

THE PHOTOGRAPHIC RECORD OF ALTERNATE-CURRENT CURVES.

In a recent number of *La Lumière Electrique* M. Blondel describes some apparatus designed for the determination of the periodic curves representing alternate currents. It consists of an extension of the apparatus originally devised by Joubert, who, it will be remembered, used a contact maker, revolving with the alternate-current dynamo, to make connection with a brush once during a revolution, and thus to charge an electrometer to the voltage generated in the dynamo at the corresponding part of the period. By adjusting the position of the brush the voltage could be measured at all

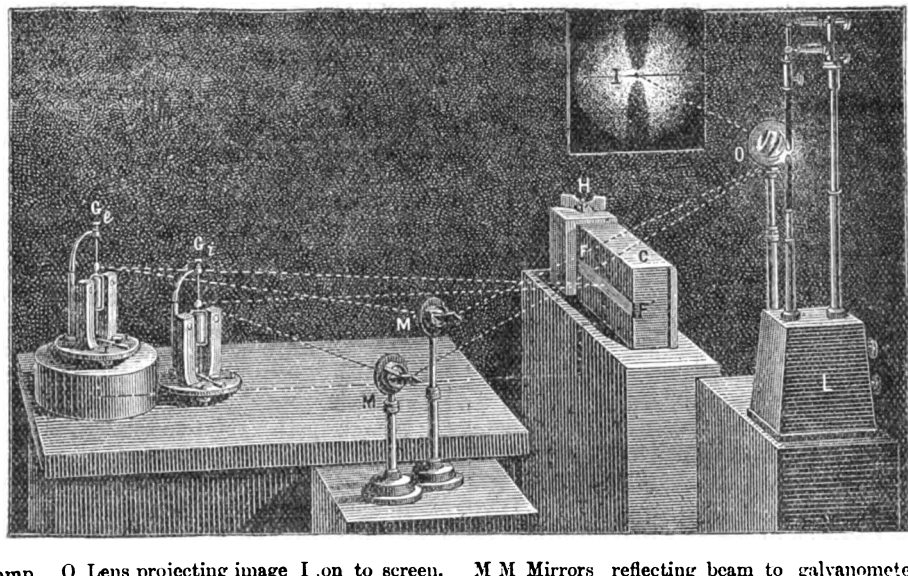

Fig. 1.—L Arc Lamp. O Lens projecting image I on to screen. F F′ Photographic registering slip. M M Mirrors reflecting beam to galvanometer mirrors G_e G_i. H Clockwork for moving the slip.

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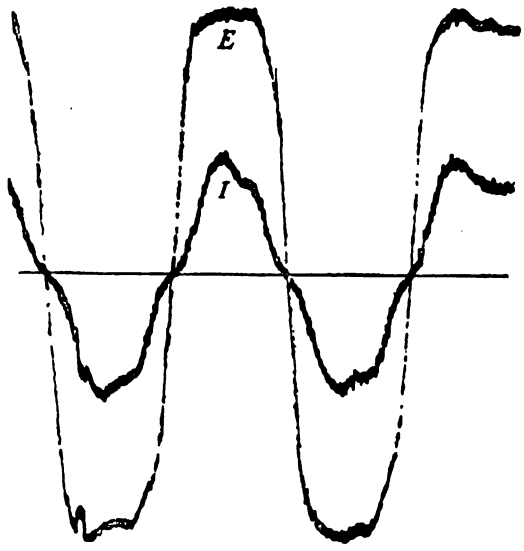
parts of the period and the complete curve obtained. After an exhaustive comparison of the effects obtained with galvanometers and electrometers, M. Blondel finds the former preferable, and uses a d'Arsonval galvanometer in series with a condenser instead of the static instrument. It is necessary in this case to use two brushes, one for charging the condenser and the second for discharge through the galvanometer. The two brushes are fixed to an arm moveable about the same axis as the revolving contact maker, and this arm is turned at a regular rate by clockwork. The scale on which the galvanometer spot is focussed consists of sensitised paper, and is moved vertically by clockwork. The photographic record obtained is, therefore, an accurate trace of the alternate-current curve. The curves obtained are potential curves, or current curves, according as the condenser is connected with two points of the circuit whose voltage is required, or to the terminals of a standard resistance in series with the main current. In all the cases described by M. Blondel the apparatus was duplicated. Two galvanometers were used, one for current and the other for potential. The spots of light were, however, focussed on the same scale with a common zero, the light being obtained from a powerful arc lamp, and reflected on to the instruments by mirrors suitably placed. The double curve thus obtained is such that corresponding ordinates represent the simultaneous values of the current and electromotive force. The figure



given shows the curves obtained with an arc lamp worked with the alternate currents produced by a Méritens magneto machine. The curve I is the current curve, while curve E represents the electromotive force.

When the apparatus is once set up it is possible in a comparatively short time to make a complete study of an alternator under all circumstances of use. A complete alternate current curve can be obtained in two or three minutes.

THEORY OF THE WIMSHURST MACHINE.*

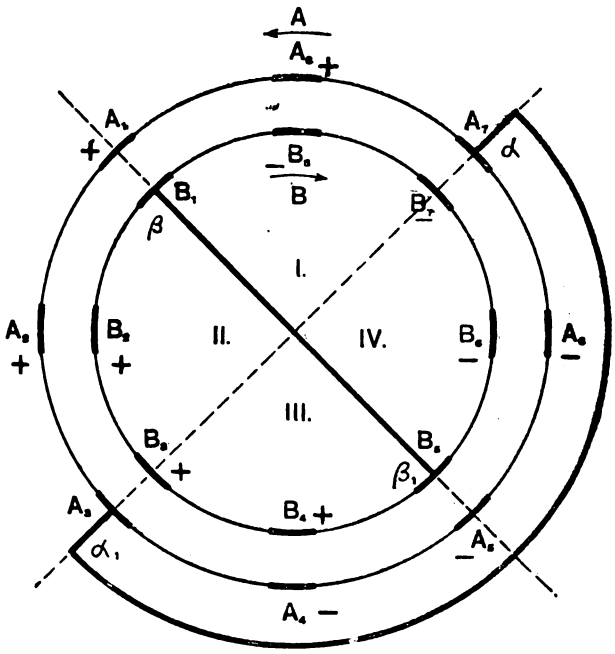
BY M. G. PELLISSIER.

The Wimshurst machine was invented about 1883, and its use has spread rapidly on account of its possessing the valuable properties of quick self-excitation, certainty of action in all weathers, and entire absence of reversal. Its theory is, however, very little understood, and M. Gariel, in his "Traité d'Électricité" has gone so far as to say that it is not possible to give it in a satisfactory manner.

It can be ascertained by experiment that a Wimshurst machine works perfectly when the combs and discharging rod are drawn back, and the action of the combs can, therefore, be neglected in the theory of the electrical action. If the distribution on the plates of the machine when it is in motion be investigated, it will be found to be as indicated by the signs in the diagram. In order to prove this Mr. Wimshurst has constructed special apparatus.

One of these instruments, the "sparking machine," is an ordinary one simplified, and consists of two glass plates carrying a large number of tin sectors very close together; these are put in motion with the fingers on a common axle held in the hand; each plate is furnished with a conductor placed along a diameter. As soon as the discs revolve, the sectors become surrounded with halos, sparks fly from point to point, and, when viewed in the dark, a very fine effect is presented. The other instrument only differs from an ordinary machine in having its plates made of an elastic material; when in motion they are seen to attract one another in quadrants I. and III., and to repel in II. and IV.

In the following Paper we have sought first to explain how the distribution shown in the diagram can be set up, and then how it is that the charges rapidly increase. In Fig. 1 the front plate is represented by the inner circle; B_1 B_2 are the sectors, of which we will assume there are eight; $\beta\beta$, the diametric conductor. The outer circle represents the back plate, A_1 A_2 its



sectors, and $\alpha\alpha$ its diametric conductor. The two wheels turn in opposite directions with the same velocity.

Let us consider one of the sectors, A_1, of the back disc at the instant that it is opposite the diametric conductor, $\beta\beta$, of the other plate; and we will assume that a sector, B_1, of the disc in front is at the same instant in contact with the brush β.

Let us suppose, without inquiring the reason, that the sector A_1 has a weak positive charge, it will induce on B_1 a negative charge, and then proceed itself towards α_1. When it arrives at this point, that is to say, after revolving through 90 deg., B_1 will, on account of the opposite directions of rotation of the two plates, have arrived opposite the brush α, which will be in contact with the sector A_5, while B_5 will be opposite A_1 at α. The charge carried by B_1 will induce on A_5 a positive charge, while A_1, which is positive, will be discharged to earth, since $\alpha\,\alpha_1$ is not insulated.

After a further rotation through 90deg. A_5 carrying a positive charge, will take the place of A_1, while B_1 and B_5 will change places. The series of actions just explained will be gone through again, and, since the induced charges are less than the original, the machine would soon cease to work.*

* From *Journal de Physique.*

* This, in fact, is what happens when combs are placed opposite A_2 B_2, and A_6 B_6 and are put to earth. If the theory of the machine under these conditions be examined, it will be seen that the second series of phenomena about to be described do not take place; the charges then diminish in geometrical progression, while the operations increase in arithmetical. It is this which points to the office of the combs in the electrical reactions.

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But A_1 does not act only on the sectors of the second plate, but also on the neighbouring sectors A_2 A_3; when they come in contact with the brush α_1 the positive charge flows to earth and they leave the diametric conductor with a negative charge which they carry towards the brush β_1. This brush acts by induction on the sectors of the second plate, which acquire a positive charge and turn from the brush β_1 in a clockwise direction.

Thus it is sufficient for the sector A_1 to have at the start a slight positive charge in order to bring about the distribution shown in the diagram. All the sectors of the back plate situated on the left between the brushes α and α_1 are positively electrified; the opposite sectors on the same plate are negative, while on the front plate all the sectors at the top between β and β_1 are negatively electrified and the opposite sectors at the bottom are positive. In the top quadrant I. the charges are of opposite sign and attract one another; the same holds good for III., while in II. and IV. the charges are of the same sign and repel one another; and if combs be placed at these points, the one on the right will collect negative electricity, and that on the left, positive.

It remains to examine how these charges go on increasing. To do this, let us take the machine in any position whatever, and consider the electrical actions that are taking place on any sector, say B_1, in contact with a brush. This sector is under the influence of (i.) the negative sectors, B_8 B_7 B_6; (ii.) the positive sectors, B_2 B_3 B_4; (iii.), the positive sectors A_8 A_1 A_2 of the back disc. Since the two first sets are symmetrically disposed, they neutralise one another, and the action of the three sectors A_8 A_1 A_2 alone remains, each of these tends to give it a charge nearly equal to its own in quantity, but opposite in sign. The sum of these actions will give to B_1 a charge that is approximately three times its original charge.

The same thing holds good for the other sectors A_8 B_5 B_7 and is renewed for each of the sectors successively. The charges will thus go on increasing in consequence of the mutual reactions up to a point that is determined by the leakage. The action of the machine being independent of the combs, it will continue to work when the knobs of the discharger are separated beyond the sparking distance. This is the explanation of the valuable property that the Wimshurst machine possesses of never failing nor reversing, as is often the case with Holtz and Voss machines.

It is necessary to add to the actions just considered the effects produced on the glass, which are far from being negligible; indeed, the Wimshurst machine can be made of two plates of polished glass, and with combs instead of brushes at the extremities of the diametric conductor. The initial charge has to be given by means of an external source, placed, for example, opposite A_1.*

This form of Wimshurst machine recalls a Holtz of the second kind; the German *savant* had, in fact, made, in 1869, a model of this apparatus, with two diametric conductors in the form of a cross, one before each plate;† he even added‡ that this machine could be made self-exciting by placing metallic sectors on the plates and substituting brushes for combs on the diametric conductors. It appears that Mr. Wimshurst was unaware of Holtz's work when he invented his machine.

The chief part played by the sectors seems to be to facilitate the self-excitation and to diminish the effect of atmospheric moisture. The greater the number of sectors, the more rapid is the excitation; thus with eight sectors, or any less number, the machine has to be excited from an external source; with 16 or 18, it rapidly excites itself under almost all atmospheric conditions; while with 40 the action is so energetic that it is very difficult to prevent the machine exciting itself even under very unfavourable conditions as to moisture. At the end of a half turn of the handle, Wimshurst machines are completely excited.

The one point that remains obscure in the theory of influence machines is the origin of the original charge. It has been ascribed to (i.) a residual charge on the plates; (ii.) electrification of the plates by friction with the air; (iii.) electrification of the metallic sectors by the natural electricity of the different layers of air, which are at unequal potentials; (iv.) electrification by contact.

Without denying the existence of these various causes the last appears the most probable, more especially since the self-excitation is only present in machines furnished with metallic sectors and contact brushes, *e.g.*, Bennet doublers, Töpler, Voss, Thomson and Wimshurst machines. It would be interesting to have exact experiments on this subject.

* In the ordinary machine, when the brushes do not touch the sectors, the machine can be made to work by starting it with a charge from an electrified body.

† *Pogg. Ann.*, t. CXXXVI., p. 171, 1869; Uppenborn's *Centralblatt, f. Electr.*, p. 683, 1883.

‡ *Götting Akad*, March, 1876. Uppenborn's *Zeitschr, f. angew, Elect.*, t. III., p. 193, 1881.

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"University College, Bristol, Calendar for the Session 1891-92." (London: Whittaker & Co.)

"The Journal of the Iron and Steel Institute, No. I., 1891." (London: E. & F. N. Spon.)

"Permanent Fortifications for English Engineers." By Major J. F. Lewis, R.E. (Chatham: W. and J. Mackay and Co,)

The C.-G.-S. System.—In a contribution to *Nature*, Prof. Perry writes:—In new applications of physics, in electrical engineering, for example, the use of the C.-G.-S. system is not only easy; it requires a large amount of ingenuity in any engineer to calculate in any other than in C.-G.-S. units, unless, indeed, he ignores all the experimental determinations already made for him and tabulated in the C.-G.-S. system. And yet such ingenuity has already been exercised, and laborious investigations have been carried out by some electrical engineers, with the result that certain parts of electrical engineering are getting to be even more unscientific in the units employed than any part of mechanical engineering. In the subject of heat, we can now ignore the steam-engine constructor; we can say to him, "Go on using your wretched pounds per square inch and your foot-pounds per minute, and we will go on using our dynes per square centimetre and our ergs per second because we are nearly independent of one another;" but we can make no such speech to the electrical engineer. We physicists have to say to him that we rely upon him to make new discoveries, to state to us new problems; and if he gives us information in vague units of his own, we cannot tabulate it for general use, and if he does not state to us his problem in the usual language, we are unable to understand him, and we can be of no mutual use to each other. But when he says to us that our language is cumbrous, that he has ideas to express for which we have no words, when he uses towards us, properly for once, that adjective "academic" which has been more misused than Shakespeare's word "occupy," the culprit and the judge change places. We can blame him if he invents unsystematic units, but not until we have given him the language and units that are correct. And in some particulars the electric engineer has the right to blame us. For example, any definition of unit electric current is so stupid that a multiplier or divisor of π or 4π enters quite unnecessarily into all electro-magnetic calculation. The engineer and experimenter care less than nothing for "magnetic susceptibility" or for "intensity of magnetisation," or for "free magnetism"; these are, to him, mementos of the time of twelve years ago, when the inventor made bricks in Egypt, and the very cleverest mathematical electricians were only distinguished from other inventors by the greater magnitude of their blunders. Dr. Hopkinson and Mr. Kapp and Mr. Bosanquet have given us simple ways of dealing with practical problems, and some of these are now known to every apprentice of an electric engineering factory; but we know of no mathematical treatise in which they are recognized.

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The Electrician.

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RAILWAY TELEGRAPHY.

Within a few hours of the recent railway collision near Burgos the Spanish Government proceeded to consider what steps should be taken to prevent the recurrence of such a catastrophe; and, after ordering an enquiry and resolving on "several drastic amendments in the railway regulations, they at once came to the conclusion," says a REUTER'S telegram, "that certain modifications were absolutely necessary. For example, the telegraphic instruments generally employed on the Spanish railways are those of the Breguet system, which admits of all sorts of misunderstandings arising, there being no printed tape or other record of the message transmitted." A meeting of the Cabinet of the Spanish Government irresistably calls to mind a picture of a council of grave VELASQUEZ grandees, with ruffs and swords and buckled shoes, and the idea of their consideration of the relative merits of the Breguet A, B, C, instrument and the Morse recorder for use in a railway signal cabin strikes one as rather incongruous. A later telegram announces that a Royal Decree was published on the 26th ult., in the *Official Gazette*, directing all railway companies to substitute the Morse apparatus for the instrument now in use on the railway telegraphs.

It is easy to imagine that the Spanish Government, having heard of the ingenious improvements which have been introduced in telegraphy, whereby tapes may be printed and records of the messages may be made, should immediately conclude that some such recording system would be highly desirable; and no doubt these views would be shared to-day by many of the English public who live among, and who hear a good deal about mechanical and electrical doings. As a matter of fact, a Morse recorder is not only practically unknown in our signal cabins, but where it has been employed in our post-offices, it is rapidly giving place to the ordinary sounder. It must be remembered, moreover, that telegraphy owes its introduction to the patronage of railways; and while railway telegraphy has become practically a separate and highly important branch of this industry, it is by no means conservatively inclined as regards introduction of new improvements.

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Telephones are extensively used to supplement the signalling instruments; and the ingenious phonopore, which has for so long struggled to gain a footing, is now at work, not on the Post-Office or on private telegraph lines, but upon the Midland and other railways, where this latest development is highly appreciated. In the early days of railways trains were signalled by means of needle instruments; but these have given place, as far as the routine work is concerned, to bell, annunciator, and other signals, including the automatic locking devices which in so many cases make it almost impossible for a careless signalman to make a serious mistake. It has long been known that recording apparatus will not prevent misreadings, and the possibility of referring to a tape, after an accident, offers but little consolation to sufferers, and no great satisfaction to the officials. A recording instrument, if not an encouragement to inattention, is, at all events, not conducive to alertness. The signals used in railway work are quite unmistakable, while the recording system, when fully developed into the type-printing instrument, occasionally relapses into a language which appears to be a dialect of Welsh.

It has been suggested more than once, that every signal, whether transmitted or received, and every lever that is pulled over or released, should mechanically record itself on a moving band of paper, on which a clock would print the hours and minutes. Such an apparatus could be easily designed by any mechanician; but experienced railway men ask, is this to supersede or to supplement the entry of such events in the usual manner? They admit that an automatic record of this kind would assist in tracing negligence to its source, but they place a high value on the definite attention to the signals which is demanded by the very fact that they must be entered up by hand, while an entirely new danger is introduced by the well-known liability of the inking arrangement to fail. We hope therefore that no false trust will be placed in the use of Morse recorders, and that an enquiry be made into the action of the Spanish officials who permitted the signals to be placed under the charge of a young man of 18, an apprentice telegraphist, who received no salary, and who was employed in miscellaneous services at the Burgos railway station.

ALTERNATING CURRENT ELECTRIC SUPPLY STATIONS.*

BY DR. J. A. FLEMING, M.A.

(*Continued from page 584.*)

§ 2. **Condensation.**—It has been shown that the application of condensers to central station engines enables much higher generating efficiency to be obtained at low loads, that is to say, that condensing plant, although it increases the economy when the steam dynamos are running fully loaded, has greater effect in reducing the loss of efficiency when they are only partly loaded. Mr. Crompton found this to be very noticeable at the Gothenburg Central Station, where there are dynamos rope driven by 200 H.P. vertical triple-expansion condenser engines. During the first year water for condensing purposes was not available, and the engines had to be run at high pressure, exhausting into the atmosphere. Although the consumption of coal was not found to be excessive at the time of highest load, yet such a saving was effected at the time of low loads, when the condensing plant was put into action, that the total fuel consumption for the year was reduced by 60 per cent. This fact has also been brought out by some important experiments made by Mr. Willans, in which he illustrates very forcibly the truth of the above statements.

Mr. Willans has made special experiments with one of his own engines, to test the effect of condensation on the steam consumption of the engine at various loads. These experiments are charted in the annexed diagram, being reduced for simplicity to the equivalents for a 100 H.P. engine. The water per hour used by the engine is represented by the vertical ordinates in Fig. 3, and the horizontal distances are the indicated horse-powers of the engine. The diagram of the water used per indicated horse-power is a straight line. The line showing the water used when the engine works condensing lies below, and parallel with the line representing the same when the engine is used non-condensing. This diagram shows that the total water used by the engine is proportional to the indicated horse-power *plus* a constant quantity, and that this constant quantity, which is the water used per hour when the engine is running unloaded, is greater for non-condensing than for condensing working. Hence it is clear that condensing increases the efficiency of the engine—that is, decreases the water used per hour relatively more at low loads than at full load. Broadly speaking, if an economy of 18 to 20 per cent. of the feed water could be effected at full load, 40 per cent., or more, might be saved at low loads. These experiments indicate the great value of condensation at low loads, as well as the immense waste incurred in water, and, therefore, in coal by working engines only partly loaded.

In the design of large stations this question of condensing ought, therefore, always to be held in view; and for that reason it is important to locate the station, if possible, in a position in which water for condensation can be procured without pumping the water a considerable distance. For surface condensers the

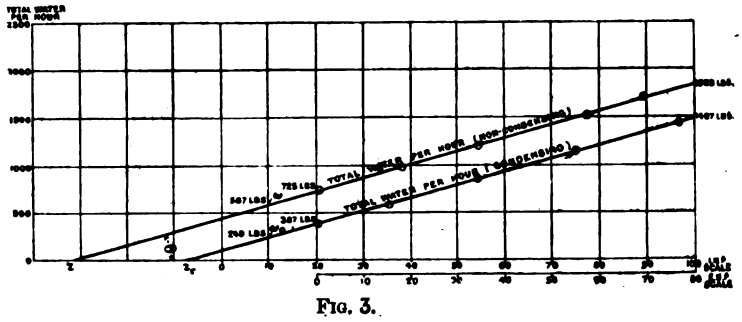

FIG. 3.

circulating water required will be about twenty times the weight of steam to be condensed, or about at the rate of forty to fifty gallons per hour per indicated horse-power, and hence, for large powers the amount of circulating water required is very considerable. In laying down pipes for the circulating water, or better still, in excavating conduits, allowance must always be made for the full extension ultimately required. In some town stations artesian wells have with advantage been sunk for this purpose; but in any case it is necessary to bear in mind the condensers must be placed in close contiguity to the engines from which they take steam, or else a considerable reduction in the vacuum in the cylinders of the engines will be found. Even if water sufficient for surface or jet condensation cannot be obtained, it is yet worth while, as Mr. Crompton has pointed out, in many cases, to put down air-condensing plant, even if such plant can only be put in of sufficient size to condense the steam at light loads, allowing the exhaust steam at the heavy loads to escape into the atmosphere. Such partial condensation would, in the opinion of many engineers, result in a considerable reduction of the whole coal bill for the year.*

§ 3. **Utilisation of Water Power.**—In many cases water power is available for the purposes of electrical generation, and in these cases the alternating current system presents great advantages in permitting the transmission of considerable quantities of electric energy at high pressures over great distances through comparatively small conductors. Considerable improvements have of late years been effected in the means by which such water power can be utilised. Amongst these may be mentioned the Pelton water-wheel, largely used in California and in other places to utilise high falls of water.

* These articles form part of Vol. II. of "The Alternate Current Transformer in Theory and Practice." All rights reserved.

* *See* Mr. Crompton on the Cost of Generation and Distribution of Electric Energy, *Proc. Inst. Civil Engineers*, Vol. CV., 1891.

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In this water motor a wheel is provided on its periphery with a series of peculiarly curved buckets (*see* Fig. 4), and jets of water are thrown into these buckets, setting the wheel in motion. The form of bucket is designed to cause the impinging water to leave the wheel with as little velocity as possible, and hence to give up nearly all its kinetic energy to the wheel. In the practical use of these wheels, water from some source is led to the wheel by hydraulic piping, often from great heights and distances. The best useful effect is found to be obtained when the bucket speed is half the velocity of the water issuing from the jet. Tests have shown that the Pelton wheel has a mechanical efficiency of 87 to 90 per cent. Hence, whenever a natural fall can be obtained, by means of which water can be delivered from one level to a much lower one, this motor enables such energy to be rendered available for conversion into electric energy. A large number of hydraulic electric stations are at work in California, using in some cases falls of water of upwards of 1,600ft. in height, the energy of which is utilised by Pelton wheels. At Aspen, in Colorado, a large electric light and power station is at work, in which some 1,400 H.P. is so utilised by Pelton wheels; amongst the other plant, Westinghouse alternators being employed for incandescent lighting. When hydraulic governors are added to control the wheel-speed, the greatest possible uniformity of driving can be attained, and the Pelton wheel shows itself to be a motor peculiarly adapted for electric lighting purposes.

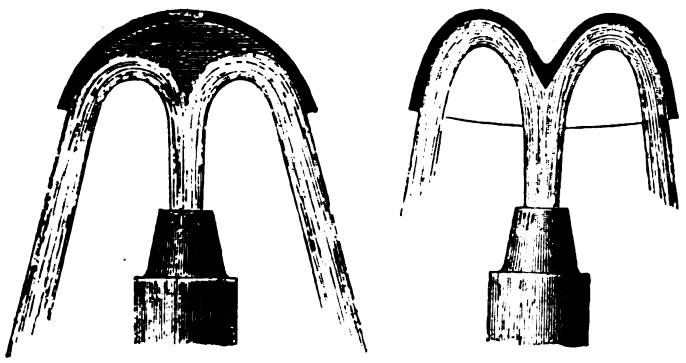

FIG. 4.

§ 4. Water Motor Installation at Tivoli, near Rome.—One of the finest examples in Europe of water-power utilisation in connection with alternating currents is the new electric station which is being established at Tivoli, near Rome. As is well known, there is at the town of Tivoli a large and valuable supply of water power, and recently a portion of this has been utilised in the establishment of a large alternating current station for 2,000 H.P., intended to supply a portion of the city of Rome with electric light. A part of the Falls of Tivoli is conducted along an aqueduct, at the extremity of which the water falls into a large iron fall-tube, 1·6 of a metre in diameter. This fall-tube is 48 metres in vertical height, and has a capacity for delivering three cubic metres of water per second. At the lower level of the fall-tube the electric station has been erected on the side of the hill, and the fall-tube, terminating near it, branches into three secondary supply tubes, which convey the water into the building. Each of these branches feeds three Pelton water-wheels, two of which are about 300 or 400 H.P. and one smaller. The six larger Pelton wheels are coupled direct to 350 H.P. Ganz alternators of the form described in Chapter II., § 1. The supply of water to each wheel is governed by hydraulic inlet valves which are worked by a sensitive hydraulic relay, the relay being set in operation by a centrifugal governor. By this means the speed is automatically kept constant, independent of the working of the machine. In addition to the six 350 H.P. alternators, there are three other direct current machines used as exciters, which are also driven direct from the smaller Pelton wheels. Each alternator is designed to furnish current at 5,000 volts pressure and 45 amperes. The machines will be driven at a speed of 170 revolutions per minute. Other arrangements for regulating the pressure are arranged as described in Chapter I. The alternating current so generated is to be transmitted to Rome, a distance of 25 kilometres, by means of four stranded copper cables, each being 100 square millimetres in cross section, and capable of carrying 120 amperes. These are to be carried overhead on iron poles placed 35 metres apart, and about 30 feet high, insulated by means of double-shed oil insulators, specially designed for this work by Prof. Mengarini. The lower part of the insulator (*see* Fig. 5) can be lowered to remove or renew the oil, and when raised into place it keeps the flanges of the upper part wet with oil, and yet renders it impossible or difficult for insects to get round into the interior. A drop of

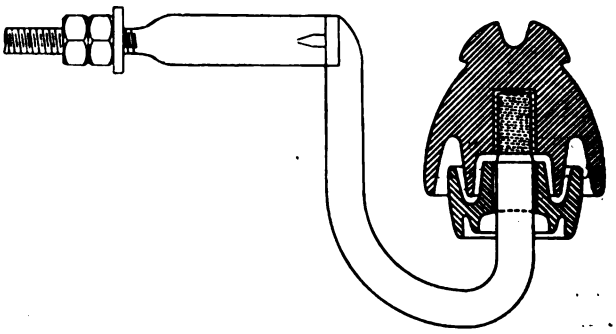

FIG. 5.

1,000 volts, or 20 per cent., is to be allowed in these lines. At the far end of these trunk mains the pressure will be reduced by step-down transformers to 2,000 volts, and distributed underground by Siemens cables to secondary centres, at which it will be again reduced to 100 volts. The six machines are all capable of being worked together in parallel, the maximum number of five being used together, and one machine being always in reserve. Two of the exciters are sufficient to supply exciting current to the whole of the dynamos, the third being a reserve.

(To be continued.)

SAYERS' PATENT PLATING DYNAMO.

We illustrate below a new dynamo, which is being manufactured and introduced under sole licence from the patentee by Messrs. T. L. Hemming and Co., of Birmingham, which has very substantial advantages for electro-plating, or any purpose requiring low pressures. Hitherto, dynamo builders have had to

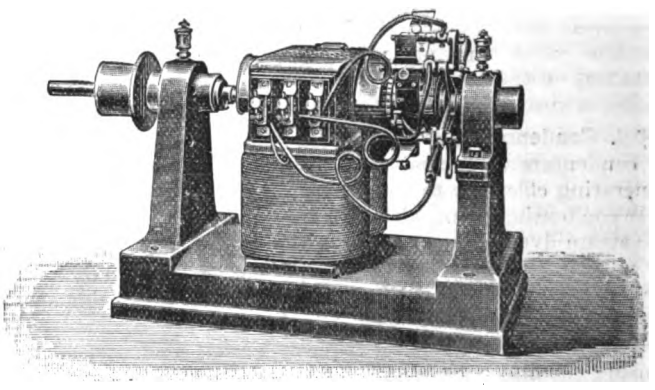

FIG. 1.—Sayers Patent Plating Dynamo.

reduce the number of convolutions on the armature, and consequently the sections of the commutator to the lowest practicable number; to reduce the strength of the exciting field, and finally to reduce the speed of the machine, until something approaching the correct voltage is reached. Generally (unless the machine is a very small one) a considerable amount of resistance must be included in the circuit in order to bring the pressure on the vat terminals down to the required value. Now, reducing the number of sections on the armature and

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working with a weak field are both prejudicial to the working of a machine as regards sparking, and the low-speed means a small output and increased first cost. The result is that up to the present machines for electro-plating have been far behind those for lighting purposes as regards sparking, and much larger than would have been required had their full capacity for generating electrical energy been available for useful work.

The novel features about the "Universal" Dynamo consist in making a number of deep channels or slots in the polar surfaces parallel to the axis of the armature and applying light subsidiary or intermediate brushes to corresponding points on the commutator of the machine; between any two of which half the total current which the armature is constructed to carry can be drawn off, at a voltage determined by the winding of the armature and the friction of the total field which is cut by the coils between the two brushes. The effect of the channels in the polar surfaces is, of course, to produce corresponding weak places in the magnetic field, with the result that the coils may be short-circuited when passing through these positions by the subsidiary brushes without any harmful effect; in fact, under certain conditions, i.e., when the current generated in the short-circuited coil by the weakened field is equal to the current flowing in the next section to which the coil is passing the sparking will be *absolutely nil*. The invention can be applied to either ring or drum armature machines, but the drum armature is the most suitable.

With a drum armature machine, no matter whether current is drawn from one side only of the commutator or from both sides at irregular positions, the distortion of the field is the same on both sides of the armature as the wires of any coil are on both sides; but with a ring armature the effect of current in one part of the armature different in value to the remainder will, of course, cause local distortion and possible sparking.

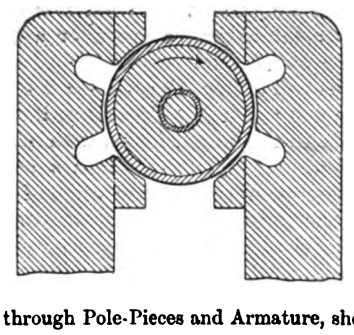

Fig. 2.—Section through Pole-Pieces and Armature, showing Air Gaps.

With a drum armature the channels on either pole-piece must be diametrically opposite, but with a ring armature the two polar surfaces may be divided into different numbers of portions so as to get different voltages on one side to those obtained on the other.

The additional brushes are not found objectionable in practice; they never have to carry more than half the current which the main brushes carry, and generally carry much less than half, so they can be made very light. With a drum armature or with a ring armature when the channels and brushes are alike on both sides, the subsidiary brushes may be connected together in pairs (the brushes, which are the same distance from one or other main brush, of course being connected together) not those diametrically opposite, except in the case of the central ones.

Under this patent Messrs. T. L. Hemming and Co. construct machines to give 10 volts at main brushes for plating with brass, say, 7·5 volts for nickel plating, and 5 and 2·5 volts for silver and copper depositing. Obviously 4 vats of 2·5 volts each can be employed if desired, the E.M.F. in either being practically unaffected by the current in the others, although the vats are connected in series. If the user desires he can connect up his vats upon the three-wire (or rather multiple) wire system; but this is not essential, as the distances are not usually great, so that separate leads can be brought to each brush from the vats. Thus in the "Universal" dynamo, while a good output can be obtained from the machine, a sufficient number of sections can be employed to secure absence of sparking.

NATIONAL ELECTRIC LIGHT ASSOCIATION.

A considerable part of the proceedings of the Convention of the National Electric Light Association of the United States is made up of speeches rather than Papers or other contributions. These speeches are not generally of a scientific, but rather of a congratulatory character, rhetoric being sought for rather than scientific accuracy. Mr. Erastus Wiman in the course of a speech said that he wished to impress on his friends in Canada the advantage that the electric system has in the transmission of power. He was in Boston on Friday, and stood in one station which had a potential of 20,000 H.P.—a power so vast as almost to be beyond human conception. Fancy, if they could, 20,000 horses under one cover, saddled and bridled and ready for a start. Fancy the forces that were latent in that potential under that roof; and yet away off in some distant avenue, by some delicate wire, it was necessary only to touch the button and the power did the rest. So it would be in Montreal.

The President, Mr. C. R. Huntley, followed the introductory orations with a practical address, in which he described a "zone system" of electrical distribution.

The idea embodied in this zone system could best be explained, perhaps, by taking a concrete, practical example, and for this purpose the present occasion made the City of Montreal an interesting one. Setting aside for the moment the possibility and even the probability of the transmission of electrical energy to the city from the power obtained at the Lachine Rapids, the President assumed a station erected at the water front of the harbour. It would, he believed, be granted that up to within a distance of one-third mile radius the three-wire low-tension direct-current system of distribution answers fully every requirement of simplicity and economy; and hence if, with the station as a centre, he drew a circle having a radius of one-third mile, he would have a zone supplied in the most economical manner for every class of light and power apparatus now familiar to them. Coming to the districts beyond the first zone, he was necessarily obliged to have recourse to higher potentials for the feeders, and the selection of the proper potential was a matter of simple calculation. He might, for the sake of this argument, call it 500 volts. Continuing on in this way, in steps of 500 volts, successive zones, half a mile across, might extend in the aggregate to several miles without reaching the limit of potentials which have been found to be perfectly feasible in practice. In the example no reference was made to the nature of the current employed or to the method of local distribution. Evidently they might readily resort to the alternating system, employing converters to reduce or raise the potential, or to the direct current reduced from high to low by motor dynamos. Either one is perfectly practicable. Perhaps some of their new school of electrical engineers would show them how to use the same circuits for both alternating and direct currents. He was convinced that the most economical way to distribute the current to the consumers at the point of delivery was by low-pressure conductors, in contradistinction to the plan now generally in vogue of giving each customer a converter of his own, or, in the direct system, a separate motor dynamo. In Buffalo they are now introducing gradually 200-light converters and replacing the smaller ones heretofore employed. Nor do they propose to stop there, but expect to instal converters of still higher capacity, distributing the current to a number of customers by low-pressure mains centreing at the large converters. As addressing himself to practical men, he need not refer to the fact that it costs practically no more labour, &c., to put up a 200-light converter than it does a 10-lighter, while the initial cost per light is less in the case of the larger converter.

With regard to the underground question, the President said that they had gratuitous advice, assistance and abuse to such an extent that less progress was made than in any other part of the work. They all want to put their wires under ground, where the number is so great as to make them unsightly or unwieldy, and not a few of them have been parties to experiments now written off to profit and loss. As soon as the time arrived when every house had its wiring as a matter of course, just as now it has piping for water and gas, it would be a comparatively easy matter to lay down comprehensive underground systems. But at the present time the customers for current

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are scattered and not continuous. The man with enterprise enough to take electric light and power soon moves into a larger store. His successor does not want the service, but gropes along with kerosine or spoils his goods with gas. Cutting out disused underground services is an added risk and expense, and 10 lights could be installed on overhead circuits for $10 where with underground the cost would be $50. It follows that in any city—Buffalo for example—they would not make one underground connection where with overhead wires they would have made twenty. Now, are the public or are we the greatest losers? The public, he thought. It was as unreasonable in most instances to demand underground wires as it was to expect every railroad to make every crossing above or below grade. But for their overhead wires, America would not be to-day the great land that it is of electrical triumphs: and, while he hailed with delight every advance in the solution of the underground problem, he hoped long to gladden his eyes with the sight of a pole well set and a wire well strung.

Another stirring question of the hour was that of municipal ownership. He believed that the most conclusive answer they could make to the sophisticated arguments of an ill-disguised socialism presenting itself in this municipal ownership scheme, was to give the very best service possible at the lowest rates compatible with fair profit.

Second Day.

The first business on the second day (September 8th) was the reading of the Report of the Committee on "The Relation between Manufacturing Companies and Central Stations." This report emanated from the Committee on Relations between Parent and Sub-Companies, and merely stated that no matter had been brought to its attention. The matter led, however, to a discussion of considerable length. Mr. Weeks recapitulated the early history of the electric industry in America, and reminded the meeting of the extravagant statements of parent companies as to the performances of their patented machinery. "These companies (said Mr. Weeks) guaranteed to purchasers: First, high efficiency; second, patent protection; and, third, exclusive rights in their respective territories. They assured investors that the new light could be produced cheaper than gas, and, in order to compete with gas and increase the demand for the apparatus, they advised continual reductions in rates of service. Companies speedily organised in the larger cities, and capital smiled on electric light investments. It was soon found, however, that various so-called systems of electric lighting were extremely crowded, and the apparatus was so short-lived that investments must be increased to meet the demand for improvement and for renewals, for which the parent companies made little if any discounts. Still, so confident were the local companies in success during future years, and so blindly credulous in the good faith of manufacturers, that the additional capital flowed in, and the parent companies were enabled to enlarge their producing powers and to increase their dividends. In the course of time it began to appear that the second claim of the parent companies, in consideration of which local companies had paid such high prices, could not be maintained. Patent protection was not given. The pioneer enterprises saw their field invaded by apparatus employing the very devices for which they had paid so liberally upon the assurance that those devices were controlled by the grantors. As the parent companies found themselves with immense producing powers, and without sufficient demand to employ them, the very powerful ones began to purchase the business and factories of the weaker, presumably to clear the field of competitors, and the temptation to violate their contracts with pioneer local companies proved to be strong. But worse treachery followed. The most outspoken of the electric light has always been gas. The parent electric companies were bitter in their denunciation of the methods employed by the gas interests in their efforts to prevent the establishment of the new industry, and until their revenues from local companies began to fail, assisted the latter in the struggle in every way which did not seriously affect their pockets. At the present time the condition of affairs is changed. The gas interests are still opposed to the electric light. But as this has shown that it has come to stay, gas companies all over the world are preparing for a new effort. They will wage war with our weapons—with cheap apparatus furnished them by our parent companies. They will endeavour to demoralise the field of electric lighting so that legitimate business cannot stand the strain. Parent companies are selling to the gas interests—and they have the effrontery in their advertisements to boast of their success—apparatus that employs the very devices whose exclusive control had been guaranteed to the interests that the new purchasers are straining every nerve to kill. And this is being done at a most critical period, when depreciation is becoming known at its full value; when, owing to the general depression, market values of service are at their lowest, and when there is a strong tendency on the part of municipalities to demand of the electric industries expensive, doubtful changes, and to curtail their privileges and reduce their rights. The manufacturing companies are indirectly and directly promoting this tendency, and are inciting municipalities to purchase plants, thus depriving local companies of that profitable service which they themselves have created. To the one hundred thousand stockholders in the local companies of America is chiefly due the establishment of the new industry. They have produced the sinews of war, and by them the battle has been fought and won. From them parent companies have derived support which has made them what they are. For this veteran service and this timely support what return do parent companies make? Having possessed themselves of many millions of our hard-earned money, they are now violating their most sacred obligation and betraying us to the enemy."

Mr. Weeks then worked himself up to a very ardent denunciation of this policy, and introduced the various analogies, Agricola and the viper, Frankenstein, Achilles, Virgil, and other classical allusions. "Let us enter into a compact," he continued, "whereby we will pledge ourselves to purchase apparatus only of those companies who will treat us fairly, and in case we cannot get such fair treatment, in case we are met by a combination, a trust or a pool on the other side, let us pledge our united support to a new manufacturing enterprise, which will enter the field with this guaranteed business to rest upon; and, Mr. President, if as a last resource, if the worst comes to the worst, let us with our upward of one hundred millions of investment call into a common fund from one to five, ten, or even twenty per cent. of our investments, and standardise our apparatus, and do our own manufacturing."

After some remarks from Judge Armstrong and Mr. Wilmerding, Mr. Francisco, who holds very strong views about the principle of municipal lighting, said that he was strongly in favour of this movement, and hoped that the central-station men of America would take hold of this as a body and carry it through as a body, united and strong; and there was no question in his mind, if they would do that, but that they will succeed and that they will support themselves without any difficulty. "It is not a warfare. That is not the idea. It is simply self-protection. That is what they are after and nothing more. They do not want to inaugurate a warfare against the manufacturing companies or the parent companies. That is not the idea. But they want to simply say to them when we have purchased a thing they have the right to use it. What they want is protection."

Mr. T. Carpenter Smith said that he was very much interested in one proposition put forward by Mr. Weeks where he spoke of forming a company for the manufacture of apparatus. He thought that in that suggestion there was a weapon that lay ready to the hand of every central-station man. They knew that there was enough machinery on which the patents have entirely run out which could be used for nine-tenths of the lighting in an electric-light station, referring more particularly to arc apparatus. The one feature in an arc machine which has been used to sell apparatus more than another and which has been used by parent companies, one against the other, was that of a good regulator. He had had some little experience—not very much—in arc lighting, and he had found that the best regulator of an arc machine was a good big load. He thought that there was not a central station in the country but that has bought and paid for enough patent regulators to take care of all their small circuits—all their cut circuits—and he thought if this committee put in

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the hands of every central station information that would enable them to buy machines which would run their full circuits and let them keep those for which they have already paid heavy prices to run their cut circuits, that they had got a weapon to bring the parent companies to a sense of what it meant to lose nine-tenths of their business at once. He felt that this committee, if it were continued, should look at the matter in that light. It was information of that kind which they want circulated among the central stations.

A motion was carried by the meeting that the Committee on Relations between Parent and Sub-Companies be instructed to formulate a definite plan of procedure for the protection of the central-station companies and prepare the necessary articles of agreement, and report the same to the Association in executive session at its next Convention.

Mr. Hornsby then read a Paper on the Chicago Exhibition, and Mr. Peck presented, as the report of the electrical section of the Committee on Data, a form by which to record data concerning street lights.

In the discussion which followed, Mr. Weeks alluded to the very inaccurate and misleading statistics which had been published by the Census Department. For instance, the statement was made that in San Francisco the price is $440·67 for one arc lamp for one year, and in Denver $58·46. Those statements were made simply without any qualification whatever. The facts were that in San Francisco, where it should be remembered coal is $7 per ton, the highest price paid for any one lamp per year is $361·90, and that was a 4,000 c.p. lamp maintained at a point remote from the central station with a considerable mileage of circuit in order to reach that point, of course. The rate that he got there was $150 within a certain radius and $216 outside and for tower lighting, two very different propositions. He had occasion to look into the matter of distribution extensively of late, and he found that the distribution of municipal lights ranges all the way from eight and six-tenths lamps per mile of line down to one lamp per mile of line. Any electrical engineer will at once appreciate the importance of this, and that element should always be included if a comparison of prices is made. Of course there were other elements that occur to almost every one—the system used, the watts consumed, the period of contract, the price of coal, whether it be water power or natural gas—but the mileage of circuit per lamp seems to have been generally overlooked. It is important in two ways—first, it determines the amount of investment. He found in the cities that he had looked up that the investment per lamp in street systems ranges from $35·87 to $190·40. They could readily see that when it comes into operation it would be still more important, as not only has the resistance of the line to be overcome, but it has to be controlled and maintained, and the trimmers have to traverse all of this distance.

The Committee on Legislation had no report to make. The design of that committee was that the members from each State would give the matters of legislation occurring within his jurisdiction to the chairman of the committee, so that it could be formulated and submitted here—a splendid scheme, said Judge Armstrong, but unfortunately it has not worked at all. He believed that the usual number of underground bills were introduced, one bill, about getting away up in the air some two or three hundred feet, was also introduced, but nothing came of any of those measures. There was another bill introduced to the effect that no wire should be operated in the State carrying a voltage of more than one thousand volts. That also died in the committee.

Dr. Louis Bell called attention to the existence of the fake electric light companies—companies existing on paper, with a board of stockholders, usually composed of the stockholders of the gas company, holding meetings once a year if it is absolutely required by law, and existing simply for the purpose of stopping legitimate electrical enterprises. They obtained charters, and they simply hung on to them, stayed there like dogs in the manger, refusing to let any electric light company get a foothold, and stopping the organisation of new companies. In the first place it is an outrage upon electrical people in general, who want to see the electric light extended, and in the next place it is particularly tough on companies which might if permitted in towns do a good deal of electric lighting. He did not know whether there could be a a reasonable possibility of legislative prevention of this, but it would be a mighty good work for this association to take up.

On the report of the Committee on Underground Conduits Mr. Francisco said that they had found that the subject of underground conduits was one that was liable to involve quite a study in relation to a great many statistics and a great many points. They went to work to get at the bottom—to get at the facts. They collected a good deal of information in regard to that matter, but the time has been so short that it had been impossible to get the report ready at this meeting. He had been in correspondence with parties in London with regard to the entire underground conduit business of London. The position that he had taken, and that the Committee took was, that if there was a system of underground wiring that was practicable and proper, they wanted to find out what was the best system, and then leave those that want to adopt it, upon the information which we may obtain, to decide as to that which was the best, the most practicable, and the most serviceable.

The report of the Committee on Safe Wiring, of which the full text is given elsewhere, was then read. Mr. Law, who had been actively engaged in preparing these rules, wished to call the attention of the Convention to the fact that they were divided into three sections. "One section says what you shall do, another section says what you shall not do, and another section says what you should do. Perhaps some of these sections that may look a little bit obnoxious to you may be those that would recommend you to do so and so, instead of saying that you shall or shall not do it. I call your attention to that," said Mr. Law, "so that you may notice these points when you come to read the rules."

Third Day.

On the third day a discussion was opened on a Paper on "Distribution and Care of Alternating Currents," which had been read by Mr. T. Carpenter Smith at the meeting of the Association at Providence, six months ago. The speakers directed their remarks to the best arrangement of fuses or transformers and the circuits in connection with them. A Paper was read by Mr. G. A. Redman on "Central Stations operated by Water Power." Various kinds of turbines were briefly described, and a number of practical suggestions as to arranging the race-ways, sluices, and other details were given.

The next Paper was that of Mr. H. Ward Leonard, "A Central Station combining the Advantages of both the Continuous and Alternating-Current Systems." The author proposes to supply a continuous current for the central portion of a town during the day time, when power is required, but to supply the outlying districts with an alternating current at night for lighting. He would thus supply current for lighting continuously throughout the twenty-four hours, but would avoid using the alternate current on a light load. But only one set of conductors is to be provided for the consumers, who are to be connected to a three-wire system. The central and the outlying portions are to be connected by switches. These are kept open during full load. The three-wire system supplies the town, and high-pressure feeders supply the transformers for the outskirts, the secondary circuit giving 220 volts, and the third wire being connected to the middle of the secondary. When the load drops at midnight, an operator is sent out who goes to each section supplied by a transformer, and by throwing a switch transfers the secondary wiring from the alternating system to the three-wire mains. In this way the small remaining load is gradually transferred to the three-wire plant, and then the alternating plant is shut down. The continuous current continues in operation all night and all the next day. In the discussion, Mr. Carpenter Smith advocated the use of alternate currents, and thought it better to have separate circuits for power and light. "Say what you will," he concluded, "it comes down to this: that it is the consumer who will regulate the running of your station. If he does not regulate it by legislation he will do it by hurting your business, by refusing to take what you supply under arbitrary conditions. And so we come back to the proposition with which we started—that no corporation, individual, or Government can say 'the public be damned' and not suffer for it."

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Mr. Burleigh followed with a Paper on "Uniformity in the Method of Keeping Central Station Accounts," which elicited a long discussion, wherein it appeared that at some stations the managers did not know at any given time how much load was being carried by the engines. Mr. Nicholls explained that this might be done with the assistance of ampere meters, and instructed the meeting how to plot the readings against time.

FOURTH DAY.

The fourth day was begun by a Paper on "Three Years' Development of Electric Railways," by Mr. Eugene Griffin, who began as follows: "The first recorded description of the electric car is found in the 4th verse of the 2nd chapter of Nahum: 'The chariots shall rage in the streets; they shall jostle one against another in the broad ways; they shall seem like torches; they shall run like the lightnings.' Notwithstanding this early mention it was not until 1888 that the electric railway became a practical commercial success. I fix the date at 1888, as it was in that year that Bentley and Knight opened the Alleghany City road to regular traffic; &c." The greater part of the Paper was historical. The author observed that Van Depoele used carbon brushes as early as 1883-4.

Considerable disappointment was expressed on the announcement that the Government had dropped the census of the electrical industry, at all events for the present; and after the usual amount of "whereas"-ing it was resolved in a very formal manner that the collection of statistics had better be begun again as soon as possible. The Report of the Committee on Safe Wiring was then read. A Paper was read by Mr. C. F. Field on "Electric Railroad Construction and Operation, and a Consideration of their Connection with Central-Station Interests." The first part of the Paper dealt with steam engines. The author thought that each unit should be entirely independent, and "this cannot be obtained in a safe and economical way by the use of our old friend the countershaft." He advocated a Corliss engine "of 500 H.P., operating at 80 or 90 turns, with a fly-wheel 18 to 20 feet in diameter, with belt centres of say 40 feet 2 inches." "On engines of this size and speed a fly-wheel capacity of approximately 600,000 pounds is about right." He alluded to direct driving, but said that "the trouble in this line has been to get electric manufacturing companies to take up the building of large multipolar generators adapted for direct coupling at a speed of from 100 to 200 revolutions."

FIFTH DAY.

On Friday, September 11th, the first Paper was that of Mr. J. L. Ayer, on "Some Details of the Care and Management of an Arc-Light System, as practised in the 'Municipal' of St. Louis." The Paper was of considerable length, and full of the practical details of running arc lamps on a large scale. Some rather astonishing revelations were made as to the inaccuracy of the ordinary measuring instruments in use in American stations. "It is rarely the practice in the smaller stations to have anything in the way of instruments except those furnished by the parent company, and possibly sometimes one outside instrument. We all know the utter unreliability of the ordinary commercial device furnished to us as an ammeter by these parent companies, and unless you do accurately know the amount of current, leaks will creep into the plant which I am sure would astonish anyone if they were to go at the matter carefully and measure them. I will give you a statement of a little test. Until I had made the test and made the comparison I could not realise that the difference or the opportunity for difference was so great. With 10 lamps adjusted to burn an average of 46 volts with 9·5 amperes of current, the average number of watts of the 10 lamps was 436 per lamp. Now, without changing the adjustment of the lamps in any manner, but simply increasing the current so that the ammeter needle read 9·8 amperes (an increase of 0·3 ampere, and you will find that the indicator furnished by our parent companies will not agree within half an ampere), with an increase of current of only 0·3 of an ampere the average consumption or increase of watts was 524, or an increase of 20 per cent. in the watts consumed. That was the result of changing only 0·3 of an ampere. When the current was increased so as to give the lamps 10 amperes we had an average voltage of 58 volts per lamp instead of 46, an average of 550 watts per lamp, or an increase of 33 per cent. in the energy consumed. There is a saving equivalent to a very handsome profit on your lamps." At another station they standardise the voltmeter and the ampere meter *every hour*.

Dr. Louis Bell remarked: "Take the best laboratory instruments and they will get out of adjustment with the most skilful use, and when they are subjected to a degree of care which could not be even approximated in the most refined commercial work. I think the cause of the error that is so frequently made in ascribing exceedingly fine regulation to commercial apparatus is due to the fact that it is not sensitive enough to show more variation. I have tested first and last in the laboratory a good many commercial instruments. I find that a good many are excellent for rough work. But the needle of a sensitive ammeter will sway through several divisions, while the indicator on the commercial instrument will not move at all. I have seen a delicate ammeter put on an arc light circuit; and then the regulator of the machine was fiddled with and see-sawed with until it ought to have changed the current by a number of per cent. As a matter of fact the commercial meter showed small changes, the accurate instrument big changes. And even those accurate instruments have to be standardised very frequently to get good results from them. There are to-day no ammeters and voltmeters suitable for portable use that can go without watching."

Mr. Orford thought that a voltmeter is quite unnecessary for incandescent work, but he was evidently an authority on arc lamps. "The arc lamp," he said, "is not such a sensitive instrument that it is going to go out because there is a variation of 10 per cent. even in your current. I think you can vary the current 10 per cent., and there is not a man in the room can tell the difference. I can give you an instance. I happen to be running a machine which is really a 65-light machine. I was competing with the Thomson-Houston. I gave them pretty good competition, and I dropped the current. I had 75 lights on the machine. I dropped my current down, and there was not a person who knew anything about it. In fact, a couple of years afterwards, one of the lamps which I had had in use happened to get into the hands of one of my former competitors, and he got it on his regular 10-ampere circuit, and he was surprised at the action of the lamp, and wondered why the lamp had changed so much since I had it. He was not aware that I was running eight amperes. My competitor was running 10. Consequently, you see that the difference of a quarter of an ampere even in a lamp is of no moment."

The last Paper by Mr. E. P. Warner, on "Different Forms of Carbons used in Arc Lighting" was not read, for want of time. He advocated single lamps with carbons 14in. long and five-eighths of an inch in diameter, and described the following experiments:—"Two single lamps were connected in series in an arc circuit, one being supplied with five-eighth inch carbons 14in. in length, the other with one-half inch carbons 12in. in length; around each lamp was branched a voltmeter indicating the voltage. The lamps were then adjusted until they had the same voltage, and as current was of necessity the same in each it was a safe conclusion that equal amounts of energy were being supplied. Photometric comparison of the two lights was then made at the horizontal and at many different angles above and below, with the result that no perceptible difference could be found in the power of the lights; during the tests the current was maintained as constant as practicable, and care was taken to base the comparison on an average deduced from a large number of readings."

A Non-electric Incandescent Platinum Light.—In a note in the *Comptes Rendus* of September 14th M. Paquelin describes an incandescent platinum light devised by him. The apparatus consists of a strip of platinum coiled on itself and placed in a platinum bowl with a hollow stem. A gaseous mixture of air and some hydro-carbon vapour is then introduced under pressure in suitable proportions. The mixture is set alight, the flame disappears, and the platinum strip incandesces, the incandescence being the more intense the greater the pressure. With moderate pressures the light is comparable with that emitted by an electric amp. The whole apparatus can be plunged into water without the light being extinguished.

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WIRING AND INSURANCE RULES OF THE NATIONAL ELECTRIC LIGHT ASSOCIATION.

A Committee of the National Electric Light Association of the United States have presented the following rules, which were adopted by the Association at Montreal, on September 10, 1891 :—

CLASS A.—CENTRAL STATIONS.

For Light or Power.

These Rules also apply to dynamo-rooms in isolated plants, connected with or detached from buildings used for other purposes. Also to all varieties of apparatus, of both high and low potential.

Generators or Motors must be—(1) Located in a dry place. (2) Insulated on floors or base frames, which must be kept filled to prevent absorption of moisture, and also kept clean and dry. (3) Not exposed to flying or combustible materials. (4) Each covered with a waterproof cover when not operating. In no case must a generator be placed in a room where any hazardous process is carried on, such as the working-room of a cotton, jute, flax, woollen, or flour mill.

Care and Attendance.—A competent man must be kept on duty in the room where generators are operating. Oily waste must be kept in metal cans, and removed daily.

Conductors.—From generators, switchboards, rheostats or other instruments, and thence to outside lines, conductors must be—(1) In plain sight. (2) Wholly on non-combustible insulators, such as glass or porcelain. (3) Separated from contact with floors, partitions or walls through which they may pass by non-combustible insulating tubes. (4) Kept rigidly so far apart that they cannot come in contact. (5) Covered with non-inflammable insulation material sufficient to prevent accidental contact. (6) Ample in carrying capacity to prevent heating. (*See* Capacity of Wires Table.) (7) Connected by splices or joints equal in carrying capacity to the conductors themselves, soldered if necessary to make them efficient and permanent. (8) When under floors or in distributing towers, placed in spaces ample for inspection and ventilation, and provided with special insulating covering.

Switchboards must be—(1) So placed as to make it impossible to communicate fire to surrounding combustible material; accessible from all sides when the connections are on the back; or may be placed against a brick or stone wall when the connections are entirely on the face. (2) Kept free from moisture. (3) Made of non-combustible material, or of hard wood, filled to prevent absorption of moisture. (4) Equipped with bars and wires in accordance with Rules 1, 2, 4, 5, 6, and 7 for placing inferior conductors.

Resistance Boxes and Equalizers must be—(1) Equipped with metal or non-combustible frames. (2) Treated as sources of heat. (3) Placed on the switch or a distance of a foot from combustible material, or separated therefrom by asbestos or cement.

Lightning Arresters must be—(1) Attached to each side of every overhead circuit connected with the station. (2) In plain sight. (3) On the switchboard or in an equally accessible place, away from combustible material. (4) Connected with at least two earths by separate wires of large size. (5) So constructed as not to maintain an arc after the discharge has passed.

Testing.—All series and alternating circuits must be tested every two hours while in operation to discover any leakage to earth, abnormal in view of the potential and method of operation. All multiple arc low potential systems (300 volts or less) must be provided with an indicating or detecting device, readily attachable, to afford easy means of testing where the station operates perpetually. Data obtained from all tests must be preserved for examination by insurance inspectors.

CLASS B.—ARC (SERIES) SYSTEMS.

Overhead Conductors.—All outside overhead conductors (including services) must be—(1) Covered with some insulating material not easily abraded. (2) Firmly secured to properly insulated and substantially built supports, all the wires having an insulation equal to that of the conductors they confine. (3) So placed that moisture cannot form a cross connection between them, not less than a foot apart, and not in contact with any substance other than proper insulating supports. (4) At least seven feet above the highest point of flat roofs, and at least one foot above the ridge of pitched roofs, over which they pass or to which they are attached. (5) Protected whenever necessary, in view of possible accidents, to conductors or supports, from possibility of contact with other conducting wires or substances to which current may leak, by *dead insulated guard irons or wires*. Special precautions of this kind must be taken where sharp angles occur, or where any wires might possibly come in contact with electric light or power wires. (6) Provided with petticoat insulators of glass or porcelain. Porcelain knobs and rubber hooks are prohibited. (7) So spliced or joined as to be both mechanically and electrically secure without solder. They must then be soldered to ensure preservation, and covered with an insulation equal to that on the conductors. The following formula for soldering fluid is approved :—Saturated solution of zinc, 5 parts; alcohol, 4 parts; glycerine, 1 part. Conductors should not be run over or attached to buildings other than those in which light or power is being, or is to be, used, but on separate poles or structures always easily inspected.

Service Blocks must be covered over their entire surface with at least two coats of waterproof paint, and so maintained. Telegraph, telephone, and similar wires must not be placed on the same arm with electric or power wires, and *should not* be placed on the same structure or pole.

Interior Conductors.

All Interior Conductors must be—(1) Where they enter buildings from outside terminal insulators to and through the walls covered with waterproof insulation, and must have drip loops outside, preferably slanting upward toward the inside and bushed with waterproof and non-combustible insulating tube. (2) Arranged to enter and leave the building through a double contact service switch, which will effectually close the main circuit, and disconnect the interior wires when it is turned "off." The switch must be so constructed that it shall be automatic in its action, not stopping between points when started, and prevent an arc between the points under all circumstances; it must indicate on inspection whether the current be "on" or "off," and be mounted on a non-combustible base in a position where it can be kept free from moisture, and easy of access to police or firemen. (3) Always in plain sight, never covered, except in special cases, where an armoured tube may be necessary. (4) Covered in all cases with a waterproof non-combustible material that will adhere to the wire, not fray by friction, and bear a temperature of 150°F. without softening. (5) In dry places, kept rigidly apart at least 10in., except when covered (in addition to insulation) by a waterproof, non-conducting and non-inflammable tubing, which must be strong enough to protect the insulating covering from injury. Conductors thus placed may be run not less than three inches apart, and be fastened with staples, under which are placed mechanically rigid insulating strips or saddles of greater width than the metal of the staple, by which possibility of injury to the tube may be prevented. (6) In damp places, attached to glass or porcelain insulators, and separated 10in. or more. (7) When passing through walls, floors, timbers, or partitions, treated as in central stations under like conditions.

Lamps and Other Devices.

Arc Lamps must be in every case—(1) Carefully isolated from inflammable material. (2) Provided at all times with a glass globe surrounding the arc, securely fastened upon a closed base. No broken or cracked globes may be used. (3) Provided with a hand switch, also an automatic switch, that will shunt the current around the carbons should they fail to feed properly. (4) Provided with reliable stops to prevent carbons from falling out in case the clamps become loose. (5) Carefully insulated from the circuit in all their exposed parts. (6) Where inflammable material is near or under the lamps, provided with a wire netting around the globe and a spark-arrester above, to prevent escape of sparks, melted copper or carbon. Incandescent lamps in series circuits, having a maximum potential of 350 volts or over, must be governed by the same rules as for arc lights, and each series lamp provided with a hand switch and automatic cut-out switch; when lights are in multiple series, such switches and cut-outs must not control less than a single group of lights. Electro-magnetic devices for switches are not approved. Under no circumstances will incandescent lamps on series circuits be allowed to be attached to gas fixtures.

CLASS C.—INCANDESCENT (LOW-PRESSURE) SYSTEMS.

300 volts or less.

Overhead Conductors.

Outside Overhead Conductors must be—(1) Erected in accordance with general rules for arc (Series) circuit conductors. (2) Separated not less than six inches, where they enter buildings as service conductors, and be provided with a double pole fusible cut-out, as near as possible to the point of entrance to the building, and outside the walls when practicable.

Underground Conductors.

Underground Conductors must be—(1) Provided with suitable protecting devices at the ends of tube or conduit services inside the walls of buildings as a guard against moisture and injury. (2) Terminated at a properly placed double pole house cut-out. (3) Of specially insulated conductors after leaving the tube or conduit, and separated by at least 10 inches, until the double pole cut-out is reached.

Inside Wiring.

Wire should be so placed that in the event of the failure or deterioration of their insulating covering the conductors will still remain insulated.

At the entrance of every building there shall be a double pole switch placed in the service conductors, whereby the current may be entirely cut off.

Conductors must not be—(1) Of sizes smaller than No. 16 B. and S., No. 18 B. W. G., or No. 3 E. S. G. (2) Lead or paraffin covered. (3) Covered with soft rubber tube. (4) Laid in mouldings of any kind in damp places. (5) Laid in mouldings with open grooves against the wall or ceiling. (6) Laid in mouldings where less than half an inch of solid insulation is between paralleled wire, and between wires and walls or ceiling.

Cleatwork is not desirable, and cleats must *not* be used unless—(1) In a very dry place. (2) In a place perfectly open for inspection at any time. (3) They are of porcelain, or well-seasoned wood, filled, to prevent absorption of moisture. (4) They are so arranged that wires of opposite polarity, with a difference of potential of 150 volts or less, will be kept at least two and one half inches apart, and that where a higher voltage is used this distance be increased proportionately. (5) There is a backing provided, of wood at least half an inch thick, well seasoned and filled, to prevent absorption of moisture.

Metal Staples must never be used to fasten conductors unless—(1) Provided with an insulating sleeve or saddle rigidly attached to the metal of the staple, and having such strength and surface as to prevent mechanical

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injury to the insulation of the conductor. (2) Under conditions in which cleatwork would be acceptable or where driven into a moulding specially adapted for open work.

SPECIAL WIRING.

Wherever conductors cross gas, water, or other metallic pipes, or any other conductors or conducting material (except arc light wires), they should be separated therefrom by some continuous non-conductor at least one inch. In crossing arc light wires the low-tension conductors must be placed at a distance of at least six inches. In wet places an air space must be left between conductors and pipes in crossing, and the former must be run in such a way that they cannot come in contact with the pipe accidentally. Wires should be run *over* all pipes upon which condensed moisture is likely to gather, or which by leakage might cause trouble on a circuit. In breweries, stables, dye-houses, paper and pulp mills, or other buildings specially liable to moisture, all conductors, except where used for pendants, must be—(1) Separated at least six inches. (2) Carefully put up. (3) Supported by porcelain or glass insulators. Moisture-proof and non-inflammable tubing may be accepted in lieu of such construction. No switch or fusible cut-outs will be allowed in such places.

Interior Conduits must not be—(1) Combustible. (2) Of such material as will be injured or destroyed by plaster or cement, or of such material as will injure the insulation of the conductor, or construction that the insulation of the conductor will ultimately be injured or destroyed by the elements of the composition. (3) So constructed or placed that difficulty will be experienced in removing or replacing the conductors. (4) Subject to mechanical injury by saws, chisels or nails. (5) Supplied with a twin conductor in a single tube where a current of more than 10 amperes is expected. (6) Depended upon for insulation. The conductors must be covered with moisture-proof material. The object of a tube or conduit is to facilitate the insertion or extraction of the conductors, to protect them from mechanical injury and as far as possible from moisture. Twin tube conductors must not be separated from each other by rubber or similar material, but by cotton or other readily carbonizable substance. Conductors passing through walls or ceilings must be encased in a suitable tubing, which must extend at least one inch beyond the finished surface until the mortar or other similar material be entirely dry, when the projection may be reduced to half an inch.

Double Pole Safety Cut-outs must be—(1) Placed where the overhead or underground conductors enter a building and join the inside wires. (2) Placed at every point where a change is made in the size of the wire (unless the cut-out in the larger wire will protect the smaller). This includes all flexible conductors. All such junctions must be in plain sight. (3) Constructed with bases of non-combustible and moisture-proof material. (4) So constructed and placed that an arc cannot be maintained between the terminals by the fusing of the metal. (5) So placed that on any combination fixture no group of lamps requiring a current of six amperes or more shall be ultimately dependent upon one cut-out. (6) Wherever used for more than six amperes (or where the plug or equivalent device is not used) equipped with fusible strips or wires provided with contact surfaces or tips of harder metal soldered or otherwise having perfect electrical connection with the fusible part of the strip.

Safety Fuses must be so proportioned to the conductors they are intended to protect that they will melt before the maximum safe carrying capacity of the wire is exceeded. All fuses, where possible, must be stamped or otherwise marked with the number of amperes equal to the safe carrying capacity of the wire they protect. All cut-out blocks, when installed, must be similarly marked. The safe carrying capacity of a wire changes under different circumstances, being about 40 per cent. less when the wire is closed in a tube or piece of moulding than when bare and exposed to the air, when the heat is rapidly radiated. It must be clearly understood that the size of the fuse depends upon the size of the smallest conductor it protects, and not upon the amount of current to be used on the circuit. Below is a table showing the safe carrying capacity of conductors of different sizes in Birmingham, Brown and Sharpe, and Edison gauges, which must be followed in the placing of interior conductors.

Brown and Sharpe.		Birmingham.		Edison Standard.	
Gauge No.	Amperes.	Gauge No.	Amperes.	Gauge No.	Amperes.
0000	175	0000	175	200	175
000	145	000	150	180	160
00	120	00	130	140	135
0	100	0	110	110	110
1	95	1	95	90	95
2	70	2	85	80	85
3	60	3	75	65	75
4	50	4	65	55	65
5	45	5	60	50	60
6	35	6	50	40	50
7	30	7	45	30	40
8	24	8	35	25	35
10	20	10	30	20	30
12	15	12	20	12	20
14	10	14	15	8	15
16	5	16	10	5	10
		18	5	3	5

Switches must—(1) Be mounted on moisture proof and incombustible bases, such as slate or porcelain. (2) Be double pole when the circuits which they control are connected to fixtures attached to gas pipes, and when six amperes or more are to pass through them. (3) Have a firm and secure contact, must make and break readily, and not stick when motion has once been imparted to the handle. (4) Have carrying capacity sufficient to prevent heating above the surrounding atmosphere. (5) Be placed in dry accessible places, and be grouped as far as possible, being mounted, when practicable, upon slate or equally indestructible back boards.

Motors.—In wiring for motive power, the same precautions must be taken as with the current of the same volume and potential for lighting. The motor and resistance box must be protected by a double pole cut-out and controlled by a double pole switch.

Arc Lights on Low Potential Circuits must be—(1) Supplied by branch conductors not smaller than No. 12 B. and S. gauge. (2) Connected with main conductors only through double pole cut-outs. (3) Only furnished with such resistances or regulators as are enclosed in non-combustible material, such resistances being treated as sources of heat. (4) Supplied with globes protected as in the case of arc lights on high potential circuits.

FIXTURE WORK.

(1) In all cases where conductors are concealed within or attached to fixtures, the latter must be insulated from the gas pipe system of the building. (2) When wired outside, the conductors must be so secured as not to be cut or abraded by the pressure of the fastenings, or motion of the fixtures. (3) All conductors for fixture work must have a water-proof insulation that is durable and not easily abraded, and must not in any case be smaller than No. 16 B. & S., No. 18 B. W.G., or No. 3 E. S. G. (4) All burrs or fins must be removed before the conductors are drawn into a fixture. (5) The tendency to condensation within the pipes must be guarded against by sealing the upper end of the fixture. (6) No combination fixture in which the conductors are concealed in a space less than one-fourth inch between the inside pipe and the outside casing will be approved. (7) Each fixture must be tested for possible "contacts" between conductors and fixture, and for "short circuits," before the fixture is connected to its supply conductors. (8) The ceiling blocks of fixtures should be made of insulating material.

ELECTRIC GASLIGHTING.

Where electric gaslighting is to be used on the same fixture with the electric light—(1) No part of the gas piping or fixture shall be in electrical connection with the gaslighting circuit. (2) The wires used with the fixture must have a non-inflammable insulation, or where concealed between the pipe and shell of the fixture the insulation must be such as is required for fixture wiring for the electric light. (3) The whole installation must test free from "grounds." (4) The two installations must test perfectly free of connection with each other.

PENDANTS AND SOCKETS.

No portion of the lamp socket exposed to contact with outside objects must be allowed to come into electrical contact with either of the conductors.

Cord Pendants must be—(1) Made of conductors, each of which is composed of several strands insulated from the other conductor by a mechanical separator of carbonisable material, and both surrounded in damp places with a moisture-proof and a non-inflammable layer. (2) Protected by insulating bushings where the cord enters the socket. (3) So suspended that the entire weight of the socket and lamp will be borne by knots, above the point where the cord comes through the ceiling block or rosette, in order that the strain may be taken from the joints and binding screws. All sockets used for wire or cord pendants should have openings at least equal to ⅛in. gas-pipe size. (4) Allowed to sustain nothing heavier than a four-light cluster, and in such a case special provision should be made by an extra heavy cord or wire, as a mechanical reinforcement. (5) Equipped with keyless sockets as far as practicable, controlled by wall switches. In no case may a lamp giving more than 50 c.p. be placed in a key socket on a flexible pendant.

CLASS D.—ALTERNATING SYSTEMS.

CONVERTERS OR TRANSFORMERS.

Converters must not—(1) Be placed inside of any building except the central station, unless as hereinafter provided. (2) Be placed in any but metallic or non-combustible cases. (3) Be attached to the outside walls of buildings, unless separated therefrom by substantial insulating supports. (4) Be placed in any other than a dry and convenient location (which can be secured from opening into the interior of the building, such as a vault) when an underground service is used. (5) Be placed without safety fuses at the junction between main and service conductors, and safety fuses in the secondary circuits where they will not be affected by the heat of the converter.

PRIMARY CONDUCTORS.

In those cases where it may not be possible to exclude the transformers and primary wires entirely from the building, the following precautions must be strictly observed :—(1) The transformer must be located at a point as near as possible to that at which the primary wires enter the building. (2) Between these points the conductors must be heavily insulated with a coating of moisture-proof material, and, in addition, must be so covered and protected that mechanical injury to them or contact with them shall be practically impossible. (3) The primary conductors, if within a building, must be furnished with a double-pole switch, and also with an automatic double-pole cut-out where the wires enter the building, or where they leave the main line, on the pole or in the conduit. These switches should, if possible, be enclosed in secure and fireproof boxes outside the building. (4) The primary conductors, when inside a building, must be kept apart at least 10in., and at the same distance from all other conducting bodies.

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SECONDARY CONDUCTORS.

The conductors, from the secondary coil of the transformer to the lamps or other translating devices, must be installed according to the rules for "inside wiring" for "low potential systems."

CLASS E.—ELECTRIC RAILWAYS.

POWER STATIONS.

All rules pertaining to arc light wires and stations shall apply (so far as practicable) to street railway power stations and their conductors.

RAILWAY SYSTEMS WITH GROUND RETURN.

Electric railway systems in which the motor cars are driven by a current from a single wire, with ground or floor return circuit, are prohibited *except* as hereinafter provided.—(1) When there is no liability of other conductors coming in contact with the trolley wire. (2) When the location of the generator is such that the ground circuit will not create a fire hazard to the property. (3) When an approved automatic circuit breaker or other device that will immediately cut off the current in case the trolley wires become grounded is introduced in each circuit as it leaves the power station. This device must be mounted on a fireproof base and be in full view of the attendant.

TROLLEY WIRES.

Trolley Wires must be—(1) No smaller than No. 0 B. and S. copper, or No. 4 B. and S. silicon bronze, and must readily stand the strain put upon them when in use. (2) Well insulated from their supports, and in case of the side or double pole construction, the supports shall also be insulated from the poles immediately outside the trolley wire. (3) Capable of being disconnected at the power house, or of being divided into sections, so that in case of fire on the railway route the current may be shut off from the particular section and not interfere with the work of the firemen in extinguishing the flames. This rule also applies to feeders. (4) Safely protected against contact with all other conductors.

CAR WIRING.

All wires in cars must be run out of reach of the passengers, and shall be insulated with a waterproof insulation.

LIGHTING AND RAILWAY POWER WIRES.

Lighting and power wires must not be permitted in the same circuit with trolley wires with a ground return, except in street railway cars, carhouses and power stations. The same dynamo may be used for both purposes, provided the connection from the dynamo for each circuit shall be a double pole switch so arranged that only one of the circuits can be in use at the same time.

CLASS F.—BATTERIES.

When current for light and power is taken from primary or secondary batteries, the same general regulations must be observed as apply to such wires fed from dynamo generators developing the same difference of potential.

CLASS G.—MISCELLANEOUS.

(1) The wiring in any building must test free from "grounds" before the current is turned on. This test may be made with a magnet bell that will ring through a resistance of 20,000 ohms, where currents of less than 250 volts are used. (2) No ground wires for lightning arresters may be attached to gas pipes within the building. (3) All conductors connecting with telephone, district messenger, burglar alarm, watch clock, electric time and other similar instruments must, if in any portion of their length they are liable to become crossed with circuits carrying currents for light or power, be provided near the point of entrance to the building with some protective device which will operate to shunt the instruments in case of a dangerous rise of potential, and will open the circuit and arrest an abnormal current flow. Any conductor normally forming an innocuous circuit may become a source of fire hazard if crossed with another conductor through which it may become charged with a relatively high pressure.

A. J. DECAMP, Chairman, STEPHEN E. BARTON, WM. BROPHY, M. D. LAW, T. CARPENTER SMITH.

Certain questions have come before the committee which they considered of too great importance to be decided at this stage. Among these are the subjects of the grounding of the neutral wire in compensating or three-wire systems; the grounding either permanently or by automatic cut-outs of the secondary wires in transformer systems; the adoption of a uniform alloy for fusible cut-outs, and the adoption of better methods for testing circuits.

From the nature of the electrical business and the rapid advance it is making, there must, of necessity, questions continually arise which can only be decided by a later and larger experience; therefore the object of the Association would be best served by the appointment of a permanent committee to whom should be referred all such questions, which they shall consider and report upon at the next succeeding meeting of the Association.

Your committee, therefore, offer the following:

Resolved, That a committee of five be appointed by the president to be a permanent committee on safe methods of construction and operation—any vacancies that may occur on the committee from time to time to be filled by the president.

WM. MC DEVITT, WM. BROPHY, T. CARPENTER SMITH, M. D. LAW.

LEGAL INTELLIGENCE.

The Electric Arms and Ammunition Syndicate (Limited).

On Wednesday last, in the Vacation Court, before Mr. Justice Jeune, Mr. Eustace Smith supported a petition presented by the shareholders for the winding up of the Electric Arms and Ammunition Syndicate (Limited), which was originally started to manufacture, under certain patents, firearms which were electrically fired. The petitioners alleged that the patents having turned out to be imperfect the firearms could not be manufactured, and experiments were now being made by the Directors for the purpose of perfecting a battery, which was an essential part of the gun. The petitioners complained that their money, instead of being expended in making and selling guns, was being spent on experiments.

Mr. JUSTICE JEUNE: Do the Company oppose the application?

Mr. MILLAR, Q.C.: Certainly. The bulk of the shareholders considered they had invested their money in what required some experiments and testing, and these were now being made. The application was made by five shareholders, all of whom were in arrears for calls, and therefore, had not complied with their own contract with their co-shareholders. The petition was launched on the footing that it was just and equitable that the Company should be wound up, but insolvency was not alleged. The Directors were honestly engaged in making the business remunerative, which they believed they would ultimately be able to do, and they objected to ruin being brought upon them at the instance of five shareholders who could not, or would not, meet their own obligations to the Company.

Mr. JUSTICE JEUNE thought it was impossible for anyone to say that the substratum of the Company had gone.

Mr. SMITH said his complaint was that he had been induced to join a company formed to manufacture and sell guns under a perfect patent, when no such patent existed.

Mr. JUSTICE JEUNE said misrepresentation might be a ground for rescission of contract, but not for winding up. The terms of the memorandum appeared to be sufficiently wide to justify the Directors in making the experiments complained of.

After some discussion, it transpired that evidence had been filed in support of the petition which had not been seen by those representing the Company, and thereupon it was arranged that the petition should stand over for a fortnight.

CORRESPONDENCE.

THE RELATION BETWEEN THE OHM AND THE "LEGAL OHM."

TO THE EDITOR OF THE ELECTRICIAN.

SIR,—An editorial note in your issue of September 11th, which I have just seen on my return to England, calls for some explanation from me. The point is as follows. It is stated on certificates issued by me as Secretary of the Electrical Standards Committee, with the sanction of the Committee, that "it has been assumed that 1 legal ohm is equal to 1·0112 B.A. units." Again, on another certificate it is stated that "1 ohm is equal to 1·01358 B.A. units"; and you point out that the ratio of these two numbers is not that of 106 to 106·3. The form of certificate referring to the "legal ohm" was adopted by the Committee in 1884 after the Paris Congress. It was then agreed to recommend provisionally the use of the "legal ohm" in accordance with the resolutions of that Congress; and the question arose, were the new "legal ohm" standards to be constructed by direct comparison with mercury units, or by comparison with the B.A. units, making use of the results then existing which connected the B.A. unit and the mercury unit? This latter course was adopted by the Committee, and after discussion it was decided to take the number $\cdot 9540 \times 10^{-4}$ as the specific resistance of mercury in B.A. units. At that date the only exact experiments on this point were those of Lord Rayleigh, which lead to the value $\cdot 95412 \times 10^{-4}$, and of M. Mascart giving $\cdot 95374 \times 10^{-4}$, and it was felt that the number $\cdot 9540 \times 10^{-4}$ represented the mean of these with all the accuracy required. The "legal ohm" standards constructed in England are all based on this number, and from it is obtained the number 1·0112 (1·06 × ·954) B.A. units as the value of the "legal ohm."

Since this date, however, many more determinations of the specific resistance of mercury in B.A. units have been made. A list of the results obtained is given in the Report of the Com-

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mittee for 1890 (B.A. Reports, p. 137), from which the following is taken :—

Rowland	1884	95349
Kohlrausch	1887	95338
Glazebrook	1888	95352
Wuilleumeier	1890	95355
Strecker	1885	95334
Hutchinson	1888	95352
Salvioni	1890	95354

The mean of all the observations made thus differs very little from $\cdot 9535 \times 10^{-4}$, and accordingly this number was adopted by the Standards Committee of the British Association (Report, 1890, p, 97), and implicitly by the Committee of the Board of Trade in their recent Report, instead of the former value $\cdot 9540 \times 10^{-4}$. Thus we have, according to the resolutions of 1884,

$$1 \text{ legal ohm} = 1 \cdot 060 \times \cdot 9540 \text{ B.A. units},$$

while, according to the best results obtained up to 1891,

$$1 \text{ ohm} = 1 \cdot 063 \times \cdot 9535 \text{ B.A. units}.$$

Hence the ratio of the ohm to the "legal ohm" as constructed in England is not 106·3 to 106. The "legal ohm" coils are all really about 5 in 10,000 too large. This has been pointed out by me in various Papers (see *Phil. Mag.*, October, 1885, July, 1891). The discrepancy to which you refer in your note is thus accounted for. In the future I suppose certificates of "legal ohms" will not be asked for, but only those of B.A. units and ohms.

These two are connected as follows :—

$$1 \text{ B.A. unit} = \cdot 9866 \text{ ohms},$$
$$1 \text{ ohm} = 1 \cdot 01358 \text{ B.A. unit}.$$

The "legal ohm" coils constructed in England do not represent—in the light of our present knowledge—the resistance of a column of mercury of 106 centimetres in length, but one the length of which is $\frac{106 \cdot 3 \times 1 \cdot 0112}{1 \cdot 01358}$, or about 106·05. They only represent the resistance of 106 cm. on the assumption stated on the certificate that a "legal ohm" is equal to 1·0112 B.A. units. This assumption further research has shown to be wrong. The resistance of a column of mercury 106 cm. long is really equal to 1·0107 B.A. units.—I am, Sir, &c.,

R. T. Glazebrook.

TO THE EDITOR OF THE ELECTRICIAN.

Sir,—As I have been favoured by you with a proof of Mr. Glazebrook's letter, I should like to say a few words in reply. The way in which the discrepancy was noted is somewhat to the point. My firm sent a true ohm to Cambridge to be certified, and it came back some ·05 per cent. wrong as compared with "legal" units, from which it had been derived on the basis 106·3 : 106, and it was only after much cross checking that the reason was found to be in the difference of definitions. Mr. Glazebrook's letter certainly explains the apparent discrepancy between the two definitions of the ohm, but it emphasises a very strong objection to the introduction of mercury at all. It amounts to this: that, during its life, the "legal ohm" changed its value; it was always 106cm. Hg., but varied according to the latest accepted value of the specific resistance of that metal.

What more cogent reason against a mercury definition could be wanted? If the accepted value of $\cdot 9535 \times 10^{-4}$ is right it has little value, as I presume it would be the very last way anyone would use to reproduce the ohm if the standard is lost. If wrong, it makes the definitions contradict one another. And if only taken as an approximate value it is not required in the presence of a much more exact one.

The "C. L." stamp is accepted not only in England but throughout the civilised world. The only definition really required is a reference to the standards over which Mr. Glazebrook has so long and so ably presided, *i.e.*, the imperial ohm = 1·01358 B.A. units. There is this much to be said for retaining the 10^{-4} definition, that it is what we think and hope is the resistance of the actual standard coil. The mercury definition as mentioned in the report to the Board of Trade (but not, I am glad to say, in the draft order in Council) makes there its last official appearance.—I am, Sir, yours, &c.,

C. W. S. Crawley.

16, Red Lion-street, Clerkenwell.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

Now Ready.—"The Electrician" Primers (38 in all. Vol. I., 20; Vol. II., 18), in two volumes. Price per volume 2s. paper covers, 2s. 6d. cloth; post free, 2s. 2d. and 2s. 9d. respectively. Single copies, 3d.; post free, 3½d. Prospectus on application to the Publisher.

Tenders, &c. Invited.—The Festiniog Local Board are advertising for plans and estimates for the supply of electricity for lighting and power purposes to the village of Festiniog and district of Tan-y-Grisiau. Further information may be obtained from Mr. R. Walker Davies, solicitor, Blaeneau, Festiniog, North Wales.

Results of Tenders.—The following is the list of tenders received for the lighting of the Market Hall, Bilston :—Lancashire and London Electrical Company, Manchester, £800; Siemens Brothers and Co. (Limited), London, £649; Walsall Electrical Company (Limited), Walsall, £625; Manchester Edison-Swan Company (Limited), Manchester, £510; Crompton and Co. (Limited), London and Chelmsford, £500; Scott (A. F.), Chelmsford, £315.

Sale by Auction.—There will be sold by auction to-day (Friday), at 132, Horseferry-road, a quality of electrical engineering plant, including engine, boiler, cable, &c., &c.

New City Offices.—Messr. Laing, Wharton, and Down, have opened new branch and City offices at 17, Gracechurch-street, London, E.C.

Messrs. Rashleigh Phipps and Dawson.—This firm informs us that they have taken possession of their manufactory for electric light fittings at Stanhope-street, Euston-road, N.W., which they claim now forms one of the largest art metal shops in London. The new manufactory is to be used in addition to the one at present occupied by the firm in Wells-mews, W.

Bankruptcy.—Under the failure of C. J. Allport, described as an electrical engineer, of Woburn-place, Russell-square, accounts have been filed, showing liabilities £14,880 19s. 1d. and assets £43 10s. The debtor states that he commenced business in 1882 as an electrical and mining engineer, with about £200 borrowed money. In the following year he entered into an agreement with others for the purchase of concessions and the right of working various lead, silver, and other mines in Servia, and he attributes his failure to loss in connection with these mines.

Messrs. Charlesworth, Hall and Co.—We are asked to notify that Messrs. Ewen and Co. have ceased to act as the London agents of the above firm; and that all communications, inquiries, &c,, should for the present be sent direct to the works at Oldham.

Messrs. Drake and Gorham.—As the result of the lighting which has been carried out at Alnwick Castle by Messrs. Drake and Gorham, it has been decided to introduce electric light to the Duke of Northumberland's town house, 2, Grosvenor-place.—The County Council have decided to introduce the electric light throughout the Newington Weights and Measures Offices, and have entrusted the work to Messrs. Drake and Gorham.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

September 10, 1891.

15,321. E. A. Claremont. Manchester. An improved electrical regulator or governor.

15,337. A. Muirhead. London. An improvement in standard electrical condensers.

15,363. H. C. E. Jacoby. London. Improvements in alternating current motors.

September 11, 1891.

15,377. J. Whitehead. Birmingham. An improved electric globe gallery and shadeholder.

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15,403. W. S. Boult. Liverpool. An improved method of actuating electrically propelled tramcars, partly applicable to other purposes.
15,407. G. Cohen. Manchester. Improvements in galvanic batteries.
15,432. T. Parker and W. Armistead. London. Improvements in electrical igniting apparatus.
15,440. Improved apparatus for periodically passing currents of electricity through a conductor.

September 12, 1891.

15,480. W. P. Thompson. Liverpool. Improvements in or relating to dynamo-electric machines. (L. Dahlmann and F. Kirster, Germany).
15,483. J. C. Mewburn. London. Improvements in electric lighting and in the means therefor. (P. Sée, France).

September 14, 1891.

15,522. G. B. Lückhoff. Croydon. Improvements in or relating to conductors for dynamo-electric machines, electric motors, and alternate or direct current transformers.
15,529. E. J. Starr. Crawley Down. Indicating the direction of the wind on a dial by means of electricity, called "an electric ane."
15,542. D. Urquhart. London. Improvements in telephones. (L. H. Despeïssis, France).
15,575. A. D. Meritens. London. Improvements in galvanic batteries.
15,579. O. March. London. An improved arrangement of automatic electric switch and cut-out for use in charging secondary cells and for similar purposes.

September 15, 1891.

15,597. C. U. Fisher. London. An improved battery. (R. H. Thompson, United States).
15,621. S. C. C. Currie. London. Improvements in the method of making the plates or elements of a secondary or storage battery.
15,645. E. T. Greenfield and C. J. Kintner. London. Improvements in and relating to ceiling blocks or roses and cut-outs for use in connection with electric light and other circuits.

September 16, 1891.

15,697. J. Graham. London. Improvements in electric telephonic transmitters.
15,705. J. Watkinson and G. Prince. Leeds. Electric signalling on railways to trains in motion or otherwise.

September 17, 1891.

15,740. W. H. Akester. London. Improvements in electric arc lamps.
15,768. C. J. Hall. Bradford. Improvements in the method of and apparatus for distributing electricity.
15,794. F. W. Dickenson. London. Improvements in electric arc lamps.

September 18, 1891.

15,834. B. M. Drake and J. M. Gorham. London. Improvement for carriers for conical shades for electric or other lamps.
15,868. H. Hegner and L. Lenczewski. London. Improvements in electric arc lamps.
15,872. The American Elevator Company. London. Improvements connected with electric motors and elevators. (Otis Bros. and Co., United States).

September 19, 1891.

15,882. H. Hearthfield. Croydon. An improved switch-holder for incandescent electric lamps.

SPECIFICATIONS PUBLISHED.

1890.

13,570. Egger. Telegraphic apparatus. (Price 8d.)
13,921. Schanschieff and Sando. Electric lamps. (Price 6d.)
14,349. Siemens, Bros. and Co. (Siemens and Halske). Electric meters. (Price 8d.)
14,433. Ford-Lloyd. Coin-freed electrical apparatus. (Price 8d.)
15,464. Sullivan and others. Governing electric light engines. (Price 8d.)
16,057. Evered and Rudling. Pillars and pendants for electric lamps. (Price 8d.)
16,223. Burrow. Electric meters. (Price 8d.)
16,963. Hartnell. Placing conductors for electricity underground. (Price 8d.)
17,631. Lauber. Electric accumulators. (Price 8d.)
17,322. Hartmann and Braun. Telephones. (Price 8d.)
17,941. Siemens Bros. and Co. (Limited) (Siemens and Halske). Charging accumulator batteries. (Price 8d.)
19,076. Mordey. Electric safety fuses. (Price 6d.)

1891.

4,468. Abel (Messing). Casings for electrical switches, &c. (Price 6d.)
5,022. Moeller. Incandescent illumination. (Price 8d.)
9,876. Coombes and Rowe. Telegraph clock systems of railway traffic control. (Price 8d.)
11,075. Mills. (Pilkington and White.) Electric meters. (Price 8d.)
11,201. Sack and others. Telephonic communication. (Price 11d.)
12,455. Welter (Bonneau). Electric locomotives. (Price 6d.)

COMPANIES' MEETINGS & REPORTS.

The Direct Spanish Telegraph Company (Limited).

The thirty-sixth ordinary general meeting of this Company was held on Tuesday at Winchester House, Old Broad-street; Mr. Edmund Etlinger presiding.

The MANAGER (Mr. Charles Gerhardi) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, before commencing the business of this meeting I wish to state—and I do so with the utmost regret—that the absence of our Chairman is caused by a sad domestic affliction, probably the greatest affliction that could have befallen him. His wife, Lady Anderson, died on Friday last. I am sure that you will all regret the cause of his absence, and will feel the deepest sympathy with Sir James Anderson in the great loss which he has sustained.

The MANAGER then read the minutes of the last general meeting, which were approved as correctly entered; and the report and accounts for the half year ended June 30, 1891, were taken as read.

The CHAIRMAN: Perhaps, gentlemen, you will allow me to go through the report, and make a few observations on the various paragraphs. The second paragraph states that "The traffic receipts show a decrease of £1,620. 10s. 6d., as compared with those of the June half of 1890." Well, gentlemen, I am bound to say that this paragraph does not quite do justice to the Company's position. It is absolutely true that we have lost £1,620, or rather that we have made less revenue to that extent than in the corresponding period of the previous year, but I must explain to you that the year 1890 was quite an exceptional year in our history. Ever since the Berlin tariff came into operation in 1886 we have had a regular steady increase in our receipts—in fact, so regular that we can say there has been a normal increase year after year, and that went on until 1890. In 1890, for reasons which I need not go into now, there was an enormous bound in Spanish traffic, and our normal increase was not only exceeded slightly, but three times over, and the consequence was that our receipts in 1890 were not normal, but were entirely abnormal; and therefore, in order to make a comparison of how we stand, we must exclude the year 1890, otherwise we shall not have a fair conception of the good position the Company occupies. Now, in 1889, as you remember, we had a very good year, but the receipts of this half year of 1891 far exceeded those of 1889, although they were behind those of the exceptional year of 1890. 1889 was better than 1888, 1888 was better than 1887, and 1887 was better than 1886. I make a stop here, because that was when the Treaty of Commerce with Spain came into operation; but as a matter of fact the half year now under review, which ended with June, 1891, shows larger receipts than any which this Company has had since its commencement in 1873, with the sole exception of the abnormal year of 1890. Therefore I take it that the shareholders may be perfectly satisfied that the Company is in a very sound and healthy position, although there is the decrease which I have mentioned in the receipts compared with those of last year, which, as I have said, was an exceptional year. Now, the question is, how shall we get on in the future? There is no doubt that our volume of traffic will keep on increasing. The trade with Spain seems to be in that state that it appears to be going up year after year; out last year, as you are aware, the Paris Conference again reduced our tariff, and from the 1st of July last, when the reduced tariff came into operation, we started, if I may say so, in a new position. We do not know, and cannot know at the present moment, how this reduction of ½d. per word will affect us. In the first place, one would naturally suppose that if people could telegraph at a cheaper rate they would telegraph more. The proportion is this: that formerly one could for a certain amount of money send eight words, whereas he can now send nine; or, to make it more practical, one could formerly send sixteen words compared with eighteen now for the same money. If, therefore, one chooses to increase his telegram slightly for the sake of clearness, we shall be in the same position as we were before; but how far that consideration will influence people it is impossible to say. Another idea that strikes me is this: that coding is naturally based on the principle of saving expense. If you go to extremes, and if you were to assume that the word-tariff was made extremely low, a point must be arrived at where people would not take the trouble to code; so that, theoretically reasoning, the reduction of the tariff will tend to reduce the coding of words from which telegraph companies suffer very much. Still, how far this will work out in practice no one can tell at present. I take it that what we have to rely on is the normal increase of traffic between Spain and England. We have no cause to believe that that will not continue, and so the point will be arrived at when the loss which we sustain by the reduction in the tariff will be counterbalanced by the increased number of words we shall be asked to transmit; but when that will come I cannot say. I now come to the next paragraph, which says, "The working expenses are £284. 11s. 9d. in excess of those for the corresponding period of last year." Although that increase is not much I should like you to see how it arises. As to £100 of it, you will remember that last year the shareholders voted to the Directors an additional remuneration in the way of salary of £200 per annum, instead of their taking a share in the profits of the Company over and above a certain dividend paid to the shareholders, to which they were entitled under the articles of association. That share of profits the Directors gave up, and thus became entitled to additional remuneration. This £100 represents half of that increased sum for six months. The difference of £184 represents the net difference on the various items of expenditure, some being more and some less; but stated roughly you may say that this £184 is the cost of the additional assistance we have required at the various stations to carry on the increased traffic and the duplex working.

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The duplex system, I may say, has been in full operation and does remarkably well. We are in this position—that the average time occupied in the transmission of a message between London and Bilbao is three minutes, and between London and Madrid twenty minutes. Considering that this message has to go overhead from London to Falmouth, under water from Falmouth to Bilbao, and overhead from Bilbao to Madrid, I think it is good work; and as a proof that others consider it good work, I may mention to you what you may regard as an interesting fact—that people in Paris frequently send messages to London to be transmitted to Bilbao by the Direct Spanish cable, and occasionally people in Paris also send messages *vid* London to be transmitted by the Direct Spanish Company to Madrid, whereas they could send by direct wire from Paris to Madrid. Sending these messages *vid* London they must travel over twice as much distance. I think this will prove two things to you. One is that your cables, instruments, and property generally are kept in good order, and secondly that your manager and staff do their work admirably well. The next paragraph reads as follows:—"With the exception of the interruption of the Barcelona cable from April 3rd to 14th, the Company's cables and the land-lines in connection with them have continued in good working order throughout the half-year. The entire cost of the repairs of the Barcelona cable, amounting to £1,695. 1s. 2d., have been paid out of the 'contingencies account.'" I have very little to say on this paragraph. Cables do occasionally break, but in this case there is a remarkable statement to be made, viz., that excepting the actual kink where the break occurred, our Barcelona cable, which has been under water since 1874, was found in very perfect mechanical condition—in fact, I understand that it is just as good mechanically as it originally was. We may therefore hope that it has a long life before it and that we shall not have much to lay out on it in the future. I think that we owe our thanks to the Eastern Telegraph Company for the promptitude with which they put at our disposal one of their telegraph ships, the Amber, which at the time was at Gibraltar. It was despatched to us almost at once, and the interruption only lasted 11 days. I think we are very much obliged to the Eastern Telegraph Company, for a Company like ours cannot keep a ship, and years ago it used to be weeks before we could engage a repairing ship, and we thus sustained considerable loss. The cost for these repairs, as the report states, has been paid for out of the contingencies account. You will remember that last year 1890 was an exceptionally profitable year. We paid a dividend of 6 per cent., plus a bonus, making 7 per cent.; but the shareholders agreed with the Board that it would be very wise to start a contingency fund which was to be applied for such contingencies as occurred this year—a break of the cable or any expense of that kind—a fund out of which we could meet these things without trenching on our reserve fund. We all agreed a year ago that the great thing was to build up our reserve fund, so that when the time came for renewing our debentures or laying an additional cable we should be in funds to effect either object. The last paragraph of our report deals with the dividend. We put, as usual, £2,500 to our reserve fund, to which is also added the interest of that fund, which is invested in securities. We next pay our debenture interest and then provide for a dividend of 10 per cent. on the preference shares. There then remains a sum with which to pay a dividend on the ordinary shares at the rate of 5 per cent. per annum, leaving us with a small sum of £270. 4s. 10d. in hand. This balance we propose to carry again to the contingencies fund. We have taken the whole of the cost of the repairs—£1,600 odd—out of this fund, and the sooner we build it up again, so as to have a fund in hand for future contingencies, the better. It is quite true that we could have paid 6 per cent. by appropriating this £270 to the purposes of dividend, but I think it would have done us more harm than good. The present moment is—I will not say critical, but one requiring a great deal of consideration and forethought. We are now working at the reduced tariff, and how that will operate on us, it is impossible to say. Naturally if you get less for what you do, you must suffer a loss, and the only way we can recoup ourselves is by getting an increase of traffic, and that is a matter which we have no control over. I think, therefore, you will agree with me in the wisdom of paying a dividend of only 5 per cent., and of carrying this odd amount to the contingency fund. I have nothing farther to say regarding the working of the past half-year. You would be glad, perhaps, to know how the three months' working from the 1st July under the new tariff has affected us. I am, however, rather reluctant to make any observation on that point, as three months' working is not enough. As you know, there have been in Spain dreadful calamities lately, and all that has caused a great deal of business for us. We have carried more words than in 1889—I again leave out 1890—but the tariff is lower. As far as money is concerned we are still losers: that is to say, the increased traffic at the reduced rate has not quite compensated us for the loss of ½d. per word; but it seems that we have a right to expect that before long the two will balance each other. I do not think I have anything further to say, and I will now propose:—

"*That the Report and Accounts now presented be, and they are hereby, received and adopted.*"

Mr. JOHN DENISON PENDER seconded the motion, which was at once unanimously adopted without discussion.

The CHAIRMAN: The second resolution which I have to propose is as follows:—

"*That the dividend at the rate of 10 per cent. per annum, less income tax, on the preference shares, and a dividend at the rate of 5 per cent. per annum on the ordinary shares, free of income tax, both for the half-year ended June 30, 1891, be and are hereby declared.*"

Mr. J. D. PENDER seconded the motion, which was unanimously carried.

The CHAIRMAN having intimated that that closed the business,

Mr. WALTER BARNETT said he thought it would be only right before the shareholders separated to pass a vote expressing their sympathy with the Chairman of the Company in his sad bereavement, for he was sure that the shareholders all sympathised most deeply with Sir James Anderson. He then proposed the following resolution:—

"*That the shareholders of this Company, assembled in general meeting, beg to tender to Sir James Anderson and his family their sincere sympathy and condolence in their sad bereavement.*"

Mr. DAVID LOWE seconded the resolution, which was carried unanimously.

The CHAIRMAN: We will forward this resolution to Sir James Anderson as soon as possible.

Mr. CHARLES BURT then proposed a vote of thanks to the Chairman and Directors for their management of the Company's affairs in the past half-year. The Chairman had given them a full explanation of their affairs, and it was always a good thing to have a Chairman who could make such a statement, as it showed that he knew all about it.

Mr. J. P. CREASEY seconded the motion, which was unanimously adopted.

The CHAIRMAN briefly acknowledged the compliment, and the proceedings then terminated.

City of London Electric Lighting (Pioneer) Company (Limited).

An extraordinary general meeting of this Company was held at Winchester House, Old Broad-street, on Wednesday, for the purpose of considering, and, if thought fit, passing the following resolution, that is to say: "That the Company be wound up voluntarily." The Lord Mayor (The Right Hon. Sir Joseph Savory, Bart.,) presided.

The SECRETARY (Mr. J. Cecil Bull) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, you will have heard from the notice which has just been read by the Secretary, the object for which this meeting has been summoned. It is my duty to tell you that the object for which this Company was formed has now been realised, and we have sold the concern to the City of London Electric Lighting Company for the sum of £75,000, clear of all deductions. I think this must be, and will be, satisfactory to the body of shareholders, and I feel no doubt that you will unanimously pass the resolution which it is intended to place before you to-day. Any question which any shareholders may like to ask I shall be very happy to answer, but I will now formally propose—

"*That the Company be wound up voluntarily.*"

Mr. J. B. BRAITHWAITE, Jun.: I have great pleasure in seconding the resolution. I think you will all agree that the shareholders of this Company will be fairly well satisfied with the result of their investment in the Pioneer Company, and still more satisfied that they have succeeded in their object, which was to undertake the efficient lighting of the City of London. This Company stepped into the breach in February last, when things were very dull, and it was necessary to make an early start and take up the matter pending the working out of the engineering and other details, and the making of the financial arrangements necessary to enable the formation of a Company adequate for the lighting of the City of London. I have much pleasure in informing the shareholders that the formation of a company with an adequate capital to light the city of London has been successfully carried out. The object for which this Company was formed has, therefore, been attained, and the shareholders will receive back the money they embarked, with a bonus of 50 per cent.

The CHAIRMAN then put the motion to the meeting in the usual way, and declared it carried unanimously. He afterwards said: I have now only to add that another extraordinary general meeting will be held in about a fortnight, and that cheques will be made out as soon as possible after the confirmatory meeting.

Mr. LEE said he thought they might fairly and properly pass a vote of thanks to the Lord Mayor and the Board of Directors for bringing the affairs of the Company to so happy a termination. He thought it must be very gratifying to the Lord Mayor, occupying his position in the City of London, to feel that his efforts had been crowned with success in bringing about the lighting of the City in the manner which had been contemplated. There was no doubt that the point had been mooted that Lord Mayors had no right to put their names upon prospectuses, or even to become Chairmen or Directors of public Companies; but this was an exceptional case and an exceptional Company. The Lord Mayor, as head of the City, had acted almost as a philanthropist in his desire to serve the City by heading the Board of Directors in promoting the Pioneer Company, which at the time was contemplated not only for the benefit of its shareholders, but also for the whole of the City of London. He thought they would agree with him that the Lord Mayor and the Directors were entitled to the shareholders' thanks.

Mr. FOSTER MACGEAGH said he had great pleasure in seconding the resolution. He felt sure that the citizens fully appreciated the fact that in a very short time they would have the advantage of the electric light in the City, especially during the dark evenings.

Mr. LEE put the motion to the meeting, and it was carried unanimously.

The CHAIRMAN: Gentlemen, I am extremely obliged to you for the vote of thanks so kindly proposed by Mr. Lee and seconded by Mr. MacGeagh; and on behalf of my colleagues I beg to thank you most sincerely for the kind expressions which you have been good enough to use with respect to our endeavours in connection with this Company. It was my firm resolution when I entered upon my term of office to join no public company; and it was only through very exceptional reasons, and through the pressure brought upon me from very high quarters, that I was induced to so far waive my resolution as to join this Company. I can assure you that it is a satisfaction to me that I am able to announce to this meeting that the work which we have in hand has progressed so satisfactorily, and that we have so far carefully protected the interests of the shareholders.

The proceedings then terminated.

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Brush Electrical Engineering Company (Limited).

The second annual general meeting of the Brush Electrical Engineering Company (Limited) was held at the Cannon-street Hotel, on Friday last, under the presidency of his Grace the Duke of Marlborough.

The SECRETARY (Mr. B. Broadhurst) having read the notice convening the meeting, the report of the Directors was taken as read.

The CHAIRMAN said: It is a somewhat difficult position that I occupy to-day, having assumed the position of Chairman of this Company for what I may say was a broken year. I have had the pleasure of being connected with the Company for three years, and have watched its progress and seen the difficulties it has had to contend with; and when we, unfortunately, lost the valuable services of our late Chairman, Lord Thurlow, the Directors were kind enough to ask me to carry on the business of the Company as Chairman for the remainder of the year; and that duty I was very pleased to accept. Perhaps, personally, it is a fortunate circumstance for me that I should be able to bring to your notice so favourable a balance-sheet as that which is now before you. It is some years since the Company was able to feel that its position was one of commercial stability, and therefore it is very fortunate for me that I should be the spokesman of the present very much improved condition of affairs. The history of your Company is a peculiar one. It was founded in 1879, and has therefore been about twelve years in existence. At that time there was an idea that the electric light was going straight away to sweep away the gas companies, and, in fact, completely revolutionise the conditions of our homes and also of our industries. That anticipation was not fulfilled. We found out, as electricians could have told the public at the time, that although there was great hope in the future, yet hundreds of problems still remained unsolved, and that not only with respect to the production of the electric light itself, but also as to its distribution, it would take years before we could place the industry on a commercial basis. At the inception of your affairs you had many valuable patents, which you sold for large sums, and your dividends were enormous. One year you absolutely paid a dividend of 100 per cent. Well, it was not to be supposed that such a state of things as that could exist without turning men's heads, and making them go beyond the limits of prudent enterprise. The consequence was that in a very few years the Brush Company got into very considerable difficulties, and the then Chairman—I think it was Sir Henry Tyler—resigned. At that time Lord Thurlow became the Chairman of the Company, and it really was a terrible time to have undertaken the chairmanship of the Board and the direction of the affairs of the Company. Not only was there the difficulty of discouragement created by the failure of early promises, but there was the extreme difficulty created by the character of the early electric light laws, which were of such a nature that it was impossible to capitalise undertakings where there was no security to shareholders that they would not be bought out at a price which would in no way pay them for their investment. To amend the Electric Lighting Act was quite an undertaking. Your late Chairman, Lord Thurlow, in conjunction with other gentlemen, was very largely instrumental in getting this Act amended and in getting other measures passed; and it is through these amendments that the electrical industry has become possible in this country in the form of public lighting. I think, therefore, that we owe our late Chairman a great debt of gratitude for having—perhaps somewhat unobtrusively—worked at this question, as he did, in the House of Lords, and for having, as he did, carried out the affairs of this Company for four or five years of considerable depression, times when we were able to pay no dividend. I think it was only in one year—1885—that a dividend was paid at all, and so matters went on, and, as you are aware, it was necessary to bring about a reconstruction of the Company. That period is now passed, and I am able to put before you quite a different prospect for the future. The turning point in the affairs of the Company was, first of all, its reconstruction; and, secondly, as I have said, the amending of the Electric Lighting Act. The object of this Company is not to do small work—what I should call retail work; but to carry out large industrial enterprises. Electric energy has many features and many sides for its development. There is electric traction, there is electric mining—in fact there are numerous ways in which the energy called electricity can be employed, but the principal reason for the existence of your Company is for the purpose of developing electric lighting centres. Now, you are going to have a gradual and, by slow degrees, an immense demand for the establishment of these large electric companies. What the gas companies did in former times electric lighting companies are going to do in the future, and there is a large field open to a Company like ours. The obtaining of the Electric Lighting Act was, therefore, invaluable to this industry. In order to be able to carry out the work of the Company, the Directors decided that it would be very advantageous to obtain some large manufacturing premises, and negotiations were carried out by which you obtained the Falcon Works, at Loughborough, in Leicestershire. Your Board have visited these works on several occasions, and have great pleasure in reporting to you that you are possessed of some very splendid manufacturing works, where you can make dynamos and engines on a large scale—in fact, as large as any works of the kind in this country. They have begun in a conservative spirit, but as the industry developes, I am sure you will approve of these works being extended. To-day the particular feature of your Company is that you are looking forward to acquire large and important orders for the carrying out of electric light centres, and that you possess the Falcon Works, where you are able to manufacture the plant for carrying out those enterprises. The policy, in fact, has been to concentrate our energies, and to get rid of outside obligations. I will mention some of those features a little later on, in a few remarks which I shall make to you then; but I will turn my attention now just for a moment to one or two small features of the report placed before you. Another of your Directors, Mr. Braithwaite, will speak on the subject of the Report itself, and analyse the particularly favourable character, financially, of the figures. The only point, perhaps, which it is my duty to insist upon with regard to the balance-sheet, is that it includes nothing except that which is fair, honest trading profit of the year. There is no profit from the City undertaking carried into this year's figures, nor anything connected with our having disposed of the Bournemouth station, nor with respect to the money we have received for the sale of certain land to the South Eastern Railway Company It is nothing more than a trading account, and it shows that in the year under consideration we have made a gross profit of £39,915, as compared with £36,698 in the previous year. This brings me to say a few words on the City undertaking. Perhaps, our shareholders do not all realise what an extremely important thing this is. Probably there is no undertaking in the whole of Europe at the present time which represents an exact parallel to the undertaking which you are concerned in carrying out. This is the only town, so far as I am aware, where the whole of the private and public lighting has been intrusted to one big Company, the City of London Electric Lighting Company, which, for the period of 40 years, thus has a monopoly. If you consider the conditions in regard to other parts of London, where Provisional Orders have been given, you will see the advantage which the City Company possesses. In every other district the Board of Trade have decided to give two Provisional Orders in every district—one, as a rule, for the continuous current, and the other for the alternating current system. That is undoubtedly, in the long run going to create complete confusion and cause disappointment to shareholders. What is going to take place is this: One company will start with one system, and when it has got a certain way towards lighting the district, another company will be formed and will put down another system, and there will be competition. It will not be fair competition, but of the character of trying to bounce one system with threatening it with competition by another. The reason it cannot be fair competition is that the streets of London do not admit of laying two sets of cables—that is, when you have laid out the system of cabling necessary to supply one central system of energy, you cannot find room to lay another network. It is exactly as if you had two telegraph companies trying to run their wires over the same district. There is, however, nothing of that sort in the City. Here you have a perfectly clear field, and there can be no competition. So long as the City Company fulfils its duties and carries out its work it has a monopoly. You will see what advantage that is to this Company when I tell you that we are interested to the extent of two-thirds in this matter. The City being divided into three parts, we have got two parts, while another group of gentlemen, who are representatives of an American firm of some position—Messrs. Thomson, Houston and Co.—have been able to obtain the other portion. However, that has nothing to do with us at the present moment. The point for our present consideration is that we are interested in two-thirds of this large undertaking; and if the City of London Company succeed in carrying out their work satisfactorily and avoid the mistakes made in some of the earlier electric lighting enterprises, your Company will get the credit of all that success, and that must eventually lead to the development which I pointed out just before, that is, the development of central lighting business, which is the main feature of our industry. I think I cannot impress on you too strongly what an immense advantage it is to you to have obtained this valuable order; and in passing I cannot help saying that I think you ought to know that you owe it entirely to the services and the persistent labours of your Managing Director, Mr. Garcke. Although your Directors have given every attention to your affairs, it would have been impossible for them to have negotiated this enterprise, but for several years Mr. Garcke has been working at this matter, and has succeeded in carrying it out. I must say that I think it is largely owing to his successful labours in connection with this matter that we are able to come forward and make such a very favourable report—not simply with respect to the balance-sheet, but with respect to the prospects of your Company generally. The next point I will allude to is the question of Bournemouth. You are aware that it was considered advisable to establish the Bournemouth business for the purpose of demonstrating what the electric light could do. There has been so much ignorance in former times as to the electric light, and it has been so necessary to push this industry, that we have been very much puzzled at certain times to know what policy to adopt; and it was considered advisable, at one period, to push a business at Bournemouth. This was successfully done. This matter ended by our obtaining a Provisional Order, and the Company carried on the work themselves—that is to say, we became the electric lighting agency under the Provisional Order. That was an unsatisfactory position, in the opinion of your Board, for a manufacturing company to be placed in; and we thought it would be more advisable, if we could to realise the values there locked up, and place ourselves in a freer position. Negotiations were, therefore, set on foot for this purpose, and they ended successfully in floating the Bournemouth Company, and the terms of that arrangement were not at all unprofitable to us. We were repaid a fair profit on our plant, and we have taken the payment of £17,275, partly in cash and partly in shares in the Bournemouth Company You are, therefore, free from any difficulties or any engagements with respect to Bournemouth; and this matter is now in the hands of a Local Board, composed of gentlemen who have local interests, and with intelligence, energy, and determination to make that business succeed. The capital of the Company formed there is £30,000, and your Company have guaranteed a dividend of 5 per cent. on that amount for a period of three years; but I do not think, judging from the returns at Bournemouth and the demand for the electric light there, that you are really incurring any risks by giving that guarantee. I now come to another feature of our industry—that is, our business at Vienna and Temesvar. At one period during the past five years it was considered advisable to acquire the Vienna business. It was acquired at a very cheap price, and a great deal of time and energy has been devoted

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to developing this Vienna business. We have a factory there which was of a temporary character, but it has been extended by our permanent works, which are now nearly finished, and a large business is being done there. Temesvar is a place whose situation is something like that of Bournemouth. We undertook the lighting of that town, and are still carrying out the business, but negotiations are going on both with respect to the Temesvar business and the Vienna factory, which may very likely end in your Company disposing of your interest in those places on favourable terms to yourselves. There is a great deal to be said against what I would call "long-arm management"—trying to manage an industrial enterprise abroad, especially in such a city as Vienna. Where you are interested as sleeping partners in a concern managed by others you need not be alarmed, but where you are responsible for the expenditure and for all mistakes you cannot manage, as successfully as people on the spot, a business like the electric light in such a city as Vienna. From my knowledge of the circumstances, if an arrangement can be carried out financially advantageous to yourselves by which you can dispose of the Temesvar and Vienna business—which has grown largely during the time it has been in your hands—you will be adopting a wise and prudent course in transferring it to others. I have only one or two other matters to touch upon. One is as to our sale of land to the South Eastern Railway Company. Negotiations went on for a long time with that Company respecting a portion of the ground on which our Lambeth works stood, and they resulted in an agreement being made for the sale of a portion of a strip of land. The agreement was carried out and the purchase money has been paid; but unfortunately the sale of that strip of land has interfered with some of the offices of the Company, and we have, therefore, been obliged to take offices for the Directors and for the commercial department elsewhere. These offices have been taken in Queen Victoria-street, near the Mansion House Station, and in the same block is a shop which belongs to the Company, in which there is a large exhibit of our manufactures. For the next few years you are possessed of these offices on lease, and the premises generally where the commercial part of the Company's affairs will be carried on. Meanwhile, the Victoria Works at Lambeth will remain as they are, so far as the construction department goes; and the technical and draughtsmen's offices will remain there. I now come to the question of the Australian business. You know that you have a branch of business in Australia, and a great deal of trouble and thought has been devoted by the Board, and also by your Managing Director, to its development. We have a manager, Captain F. Rowan, who represents us there, and does all he can to develope our interest on that side of the world. It might seem that there was not a great deal to be gained just at present by establishing such a branch of our industry, and yet when we think of it, we must see that it cannot be our Colonies that will develope this new business unless we go in first and start it. There is no doubt that the Colonies will largely require all the things which we can supply them with and which they will not be in a position to provide for themselves; and although there is not at present a very large demand, there is a satisfactory demand springing up, and the business is a growing one. I therefore think that in a few years time you may hail with great satisfaction the fact that your Board were inspired with the idea of getting early into the Australian field and obtaining a large amount of the custom of our cousins on the other side of the world. I think that, although the profit on the first year's work is not large, it affords us an indication of what the working of this business may eventually tend to, and I think we may fairly look forward with hope to the development of a very considerable business in Australia and in the Colonies in the course of the next few years. We are really only at the commencement of the development of this marvellous invention. Ten years have gone by, and manufacturers on one side, and men of science on the other, have been trying to thresh out this question of electricity. It has been in the hands of mathematicians one day, and "chucked" at the heads of engineers the next; but we are now getting out of that state of things. The engineers—that is, the men of business—and the professors are agreed, and have come to the conclusion, practically, that we now know where we are moving. It is simply now a question of expense. When the public can afford to find the money for the lighting of their towns by electricity, we, the Brush Company, and other companies are in a position to solve the problem for them. There is no doubt about that. Ten years ago, when this Company paid its 100 per cent. dividend, we were not in that position. To-day you have an established industry. It is in an essentially conservative sense that your Directors do not recommend that the thing should be pushed or "boomed" in any way; but they feel, on the other hand, that it is simply a question of time and expense when they will be able to obtain any number of orders they require, and to be able to do a thoroughly good business, and one very remunerative, in every sense of the word, to the shareholders of the Company. I feel no hesitation, therefore, in speaking in the most hopeful way with respect to the future. I may just say, in passing, that, as compared with the average of five years preceding the reconstruction of the Company, the volume of business has increased in the ratio of 100 to 288—that is, nearly 200 per cent.—while the standing charges have only increased in the ratio of 100 to 113, or, say, 13 per cent. You see that the policy of your Board has been to keep down, as far as possible, the standing charges, and not to let them run ahead of our business. The gross volume of our business has increased, and the fixed charges have been very stationary. You will observe, therefore, that I am right in saying that our policy has been an essentially conservative one. I think I need not keep you any longer, but I will leave to Mr. Braithwaite and other Directors to point out the financial features of the balance-sheet. I think I may conclude by saying that you have before you every prospect of a successful year, and I hope that the next time we meet we shall be able to present quite as successful and prosperous a report as the one laid before you to-day. You are aware that we have not only lost the services of Lord Thurlow as Chairman of the Board, but we have also lost, I am sorry to say, the invaluable services of Mr. John Sellon, who was for so many years connected with this Company. It was with great regret that his co-Directors lost his help; but he was unable, owing to his many engagements and the large amount of business which he has to conduct, to continue to give his personal attention to the affairs of the Company. It is now my duty to conclude by moving:

"That the Report of the Directors and the Statement of Accounts to the 30th June, 1891, as now presented to the shareholders, be received, and the same be hereby approved."

Mr. J. B. BRAITHWAITE, jun., in seconding the motion, endorsed the remarks of the Chairman that the balance-sheet was purely a trading, and not in any way a speculative one. The results shown had been entirely derived from their ordinary trading, and not one penny of credit had been taken in the balance-sheet in connection with the City of London Order, or from the sale of the Bournemouth business or the sale of land at Lambeth to the South Eastern Railway Company. It would not have been right to have included such items, but he merely desired to point out that the profits shown were entirely from the business. If they concluded that that was a favourable balance-sheet, drawn up on such lines, they might look forward with considerable satisfaction to any future balance-sheets the Directors might present. There was one great change in the balance-sheet this year, and it had been made at the suggestion of their auditors. They had rendered a separate balance-sheet connected with their foreign and colonial branches, and it showed a balance of assets over liabilities of £64,530, which they brought into the general balance-sheet. In the general balance-sheet itself it would be noticed that their capital had been increased in the year by £5,000, which was the remaining payment they had had to make to acquire the Australian business. There was an item on each side of the balance-sheet connected with the City of London Electric Lighting (Pioneer) Company. On the debit side the item was £34,892, which represented money they had received from the Pioneer Company and others, as advances in order to go on with the City of London work; and on the other side of the balance sheet the item of £21,070 was the amount which, up to the date to which it was struck, they had spent on this work. Now that the City company had been formed, these items would disappear in future from the balance-sheet. The £21,070 was the amount spent on the work, and did not include any item of profit—not even ordinary trading profit. They had begun the formation of a reserve fund—a fact which he was sure they would be glad to hear, and he hoped that every year it would be increased. Perhaps some of them might think that the amount, £4,275, was so small that it was not worth while to have shown it; but he regarded the entry with much satisfaction; and the amount represented a portion of the money they had received from the sale of the properties. They might call this a cash reserve to start with, and it would be the policy of this Board to increase this fund as opportunities offered, until it amounted to such a sum that they felt they had attained a position of financial stability. The property account was largely reduced as compared with last year, but the details of this were given in the report. Passing to the profit and loss account, he stated that it would be seen on the credit side that the gross profit, including the net profit of the foreign and colonial branches, had amounted to the very respectable sum of £39,915 during the year, in spite of the fact that the Managing Director and a good many of their officers had had a great deal of their time taken up in connection with the City lighting, the results from which would not appear until next year. Their standing charges had been reduced compared with those of last year, almost every item showing a reduction. There was a new item on the debtor side of the profit and loss account to which he thought their attention should be directed—he referred to the item of "staff bonuses," £759, and he hoped they would all agree with the policy of the Board in this matter, which represented, in fact, the adoption by them of the profit-sharing scheme. As far as it had gone they had every reason to be satisfied. They commenced the scheme by placing on it all their chief officers. They had now put on another series, and this year they would be able to still further extend the benefits of the scheme to all their foremen, and possibly to all the men who had been any length of time with them. Eventually they hoped to extend it to every man in their employ. In view of the nature of their manufacture, and how much depended on the care and skill of their workmen, he regarded it as not only right but also expedient to give every man an interest in the profits. With reference to the appropriation of the profits, they proposed to distribute a dividend on the ordinary shares amounting to £7,018. To show how thoroughly honest and business-like the balance-sheet was he desired to call their attention to the fact that in addition to paying this £7,018 in dividends, they had written off against revenue other items equal in amount to it. It was perfectly right to have done this, but he thought the shareholders ought to see that if the Board had cared to do so they could easily have paid another £7,000 to their shareholders, but he thought they would agree with him that the amount written off was right. They wrote off, first, £3,000 against property, and then £630 against preliminary expenses, reducing them to about £630, which would be finally extinguished next year. There then remained £306 to carry forward, and in the profit and loss account they wrote off against the revenue the whole cost of maintenance of plant and buildings, £2,184, and of the patents £480, as well as the whole of the loss incurred by closing the Cardiff Station, £447. The closing of that station was not owing to the fact that it was not answering, but to the fact that the Corporation of Cardiff refused to let the Company apply for a Provisional Order for lighting the town, and that the Board of Trade declined to allow them to continue their lighting without the consent of the local authorities. They had, therefore, been in the position of not being able to light the place themselves, while no one else had been willing to do so. They therefore had no alternative but to close the Station. If the Corporation of Cardiff should ultimately decide

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to undertake the lighting of the town it was by no means unlikely that they would come to the Company. They had thus written off against revenue in connection with these items, an amount equal to the sum they would distribute on the ordinary shares. It gave him great pleasure to second the motion for the adoption of the report.

Mr. E. K. SMART said he thought that instead of saying in the report that they recommended a dividend at the rate of 6 per cent. per annum for the half-year, it should have been 3 per cent. for the year, for there was no doubt that the dividend proposed by the Directors had been earned in the whole twelve months. With reference to the Debentures, he hoped that as the Company was in a much firmer position, an effort would be made to reduce the interest, 6 per cent. being too much for a stable company to pay on debentures. He thought that the amount of property and plant should be stated separately from the goodwill and the amount paid for patents. With regard to the gross profits, the Company had been in active operation for the whole twelve months, and had done as much business as possible, and yet the gross profit was only 9 per cent. on the capital of the Company.

Mr. WEIR wished to express his great satisfaction at the condition of the Company. He was an original shareholder of the Brush Company, and had followed the career of the Company for ten years. They now appeared to have passed through the experimental stage, which was always a very trying stage, and they had arrived at the producing stage. He hoped they would continue to have plenty of work to keep their machinery engaged. He was glad they had adopted the profit-sharing system among the heads of departments, and that they were going to extend it, for he was sure that that was the way to avoid strikes. He had been glad to hear the Chairman speak so highly of the services of Mr. Garcke, and he thought the shareholders ought to congratulate themselves on seeing that that gentleman occupied the position of their Managing Director. Mr. Garcke had stood by the Company throughout, and he hoped that he would continue to do so, and that he would share very handsomely in the profits. With respect to the previous speaker's observations regarding the dividend, it mattered not whether it was for three months or twelve months so long as they received a fairly-earned dividend. He desired to ask whether any progress had been made in the use of electricity for light railways and tramways, and whether their machinery was suitable for light railways, such as were now being constructed by the Government in the West of Ireland.

The CHAIRMAN: With respect to the few remarks that have been made, and the few questions asked, I will reply to them *seriatim*. As to the question about the dividend, I think that the last speaker answered it. The dividends are paid half-yearly, and the dividend has been paid practically for the last half-year. If you like to say that it is 3 per cent. for the whole year instead of, as we say, 6 per cent. per annum for six months, it is a matter of opinion. As to the rate paid for debenture interest, undoubtedly I think that the day will come when we shall be able to fund that debt on more favourable terms; but when these debentures were issued the conditions were totally different from those now prevailing. It is of no use counting your chickens before they are hatched, but I hope that our position will improve considerably as time goes on in this respect. With regard to the gross profits being only 9 per cent. on the whole capital of the Company, you must remember that the Company has gone through some very considerable vicissitudes, and that as to a great deal of that capital, though it will earn a dividend in the future, it has, to a great extent, been spent on building up the enterprise you now possess. It was not to be supposed that every shilling of expenditure would be remunerative. You have had to pay for litigation, you have made mistakes, and there have been all sorts of things to contend with; and you will have more mistakes. I hope you will have less litigation. It is impossible not to have mistakes, but the industry promises to grow, and it will carry all the money it has required to acquire the experience that we have gained. I think you will see less capital expenditure in future, and larger returns. With respect to the division of the item of "property, patents, and goodwill," you must remember that that item of £266,270 represents what has been paid by you for these things. It is no use to divide these items out into the numberless headings they represent. We could put out the money paid for patents, for premises, and for goodwill; but in a statement of this sort we cannot distinguish, and it appears as one item. We took this all over from the old company, and we have it entered at that figure, but we have not set it out as so much for patents, so much for premises, and so much for goodwill. It is a bargain that we have made, and it will not look any better if we divide it out. As to the question of the tramway business, that is a very important feature in electrical industry. We are very anxious indeed to develope the electrical traction business. We have one contract which we are carrying out, which I hope will be successful; and some of our technical staff have only lately returned from America, where they have been giving close attention to this question. Mr. Mordey has only just returned from America, and has brought us full details with respect to electrical traction there. In America electrical traction has taken an immense start. There is sure to be a large demand grow up for light railways on electrical principles in outlying districts, such as in the West of Ireland. The Falcon Works we took over were originally a car company, and the car-making feature has been preserved by us. We are making cars, and our technical staff are giving as close attention as they can to the development of electricity for tramways, and we shall try and obtain a fair proportion of the orders given by the public for tramway cars and light railways in the future. That answers all the questions asked, and it is now my duty to put the motion to the vote.

The resolution was carried unanimously.

The CHAIRMAN proposed:

"*That the interim dividend at the rate of 6 per cent. per annum paid upon the preference shares of the Company for the six months ended December 31st, 1890, be confirmed; and that a dividend be declared upon the preference shares and upon the ordinary shares of the Company at the rate of 6 per cent. per annum for the six months ended 30th June last, and that the same be paid on 1st October, 1891.*"

Mr. BRAITHWAITE seconded the resolution, which was unanimously agreed to.

On the motion of Mr. B. H. VAN TROMP, seconded by A SHAREHOLDER, the Duke of Marlborough and Mr. Aymor H. Sanderson were re-elected to their seats at the Board; and the Auditors (Messrs. Cooper, Bros. and Co.) were subsequently re-appointed.

Mr. WEIR then proposed and Mr. DURRANT seconded, a vote of thanks to the Chairman and Directors.

The resolution was unanimously passed.

The CHAIRMAN: As Chairman, and as representing the Directors, it is my duty to thank you very sincerely for your kind acknowledgment of our efforts on your behalf. You may be quite sure we shall continue them, and, in fact, increase our efforts to produce the success which we are certain will attend the operations of the Company during the present year.

The meeting then terminated.

NEW COMPANIES, STATUTORY RETURNS, &c.

ATLAS CARBON MANUFACTURING COMPANY (LIMITED).—This Company was registered on September 24th, with a capital of £2,000 in £1 shares by Slaughter and May, 21, Great Winchester street, E.C. The objects are, to manufacture, sell and deal in carbons, glass, india-rubber, vulcanite, iron, copper, and other metals, electric conductors and non-conductors, and all machinery, plant, apparatus and appliances necessary for the generation, distribution and accumulation of electricity; to enter into an agreement with W. J. Woodward; to enter into any contracts for the supply of electric light and energy; to acquire the right to use, manufacture, or put up telegraphs, telephones, phonographs, electric bells, and all kinds of electric apparatus. Registered without special articles.

JEWISH COLONISATION ASSOCIATION.—This association, which was registered on September 10, 1891, with a capital of £2,000,000 in £100 shares, includes, among the objects of its incorporation, the forming of Jewish colonies in various parts of North and South America and elsewhere, for agricultural and commercial purposes, and the construction, establishment, and maintenance of all roads, tramways, railways, bridges, harbours, fortifications, gas and electric light works, telegraphs, telephones, and other works of a public or private character. The management of the association will be under the control of a "Council of Administration," with offices at 17, Old Broad-street, London, E.C.

LAW'S ELECTRICAL APPLIANCES COMPANY (LIMITED).—This Company was registered on the 23rd September, 1891, with a capital of £4,000, in £5 shares, by Davidson and Morriss, 40 and 42, Queen Victoria-street, E.C. The objects are: To enter into an agreement with Edward F. Law, and to work the inventions, patents, and rights (particulars of which are not given) mentioned in a draft of the agreement, to enter into an agreement with William Clowes and Sons, Limited; to carry on the business of type setters and compositors, by machinery and otherwise, printers, lithographers, telegraphists. The first Directors are Major E. F. Law, Sinclair Macleay J. T. F. Otway and S. H. Isles. Solicitors, Davidson and Morriss.

TRENT CYCLE COMPANY (LIMITED).—This Company has been registered with a capital of £10,000. The chief object of the Company is to manufacture and deal in cycles, and, in addition, to carry on the business of mechanical and electrical engineers, machinists, wire-drawers, tube-makers, galvanisers, electro-platers, and other businesses incidental to the manufacture of cycles.

JOSIAH WADE (LIMITED).—This Company has been registered with a capital of £20,000, and included in its objects are those of mechanical and electrical engineers, machine and tool makers, boiler makers, iron founders, printers' furnishers, &c.

CHARLES WALMSLEY AND COMPANY (LIMITED).—This Company was registered on September 25, 1891, with a capital of £30,000, in £5 shares, by Hooper and Son, 69, Ludgate Hill, E.C. The objects are to acquire and take over as a going concern and carry on the business of a mechanical and electrical engineer and machinist, now carried on by J. Smethurst, under the names of Charles Walmsley and Co. and the Atlas Ironworks Company, at Elton, Bury, in the County of Lancaster. The first Directors are: C. Walmsley, J. Byrom, J. Cronshaw, T. Thornley, and T. Holt, all of Bury. Qualification, £500. Solicitors, Butcher and Barlow, Bury.

CITY NOTES, &c.

ANGLO-AMERICAN TELEGRAPH COMPANY.—At a meeting of the Board of Directors of this Company on Friday last it was resolved to declare an interim dividend for the quarter ended September 30th of 12s. 6d. per cent. on the ordinary stock, and £1. 5s. per cent. on the preferred stock, less income-tax, payable on October 31st to the stockholders registered on the books of the Company on September 30th.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the past week were £4,915.

CALLENDER'S BITUMEN TELEGRAPH AND WATERPROOF COMPANY (LIMITED).—An interim dividend of 5s. per share has been declared by the Directors of this Company, payable on October 31st.

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CITY AND SOUTH LONDON RAILWAY COMPANY.—The traffic receipts of this Company for the week ended September 27 amounted to £708; aggregate receipts for half-year to date, £8,917.

THE HALIFAX AND BERMUDAS CABLE COMPANY.—A private meeting of this Company was held on Wednesday last, to which reporters were not admitted.

SUBMARINE CABLES TRUST.—Notice is given that on and after the 15th inst. the balance of the coupon due in April last (£2) will be paid by Messrs. Glyn, Mills, and Co., of Lombard-street, E.C., between the hours of 10 a.m. and 2 p.m. The coupons should be left with the bankers for examination four clear days before payment. The certificate holders are requested to present the coupons for April only, and not those payable on October 15, 1891.

THE RISE IN ELECTRIC LIGHTING SHARES.—The *Observer* of the 27th ult., commenting on the recent rise in the price of electric light companies' securities, says:—In 1882, electric light companies, with a combined nominal capital of 25 million pounds, were introduced to the public, and a boom in electric light shares generally took place. The results obtained in the way of dividends by those companies who started business were not encouraging, and the shares steadily declined in popular favour, until the Board of Trade, after a long inquiry into the claims of the various companies for lighting certain Metropolitan districts, divided London into suitable areas. From that time certain of these undertakings have been quietly receiving the attention of investors who believe in the dividend-earning possibilities of the electric light. Prices have thus steadily advanced and show a considerable rise on last year's quotations. Below are the highest and lowest prices of the shares in 1890 of the electric light companies quoted in the official list and the price to-day:—

	Paid on shares.	Price 1890. Highest.	Price 1890. Lowest.	Price Sept. 26th.
Brush Electrical	£3	2 15/16	1¼	3⅜
Electric Construction	£10	8½	7⅛	6⅛
Metropolitan Electric	£10	*8½	5¼	10½
Swan United	£3½	4 1/16	5⅜	5½
Westminster	£5	—	—	6¼

* £8 paid.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended September 25th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,833.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Sept. 23.	Price Wednesday, Sept. 30.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Sept. 30. Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
£1,300,980	Stock	12/0	Anglo-American	48 49	48 49	5 12 3	Jan., Apr., July, Oct.	49	48½
£2,849,510	Stock	24/0	Do. Preferred	86 87	87 88	6 2 2	" "	87½	86⅝
£2,849,510	Stock	5/0	Do. Deferred	13½ 13⅝	13 18½	..	.. ..	13⅛	13
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99 102	99 102	3 18 5	January and July ..	..	..
130,000	£10	5/0	Brazilian Submarine	11¾ 12¼	11¾ 12¼	6 18 9	Mar., June, Oct., Dec.	12⅛	11¾
£69,200	£100	5%	Do. 5 per Cent. Bonds	99 102	99 102	4 18 0	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107	103 107	4 18 6	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock xd	120 123	122 124	5 8 10	April and October	..	..
16,000	10	8/0	Cuba Submarine	10½ 11½	10½ 11½	6 19 2	February and August	11	10⅞
6,000	10	10%	Do. Preference 10%	17 18	17 18	5 11 1	" "	..	..
12,931	5	3/2½	Direct Spanish (£4 paid) xd	3½ 4	3½ 4	7 0 0	April and October	..	..
6,000	5	10%	Do. Preference 10% xd	9½ 10½	9 10	5 0 0	" "	..	..
60,710	20	3/6	Direct United States	10⅛ 11⅛	10¼ 11¼	6 5 10	Jan., Apr., July, Oct.	11⅛	11
400,000	10	5/6	Eastern	14¼ 14⅝	14¼ 14⅝	4 10 5	" "	14⅝	14¼
70,000	10	6%	Do. 6 per Cent. Preference	15 15⅝	15 15½	3 17 5	" "	15⅝	..
£1,200,000	Stock	6%	Do. 4 per Cent. Mort. Debenture Stock	107 110	107 110	3 12 9	May and November	..	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	107 110	4 10 11	February & August	..	..
250,000	10	2/6	Eastern Extension	14⅞ 15⅛	14⅞ 15⅛	4 12 7	Jan., Apr., July, Oct.	15 1/16	..
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock	106 109	106 109	3 13 5	February & August	..	..
£85,800	100	5%	Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	104 107	104 107	4 13 6	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	102 105	102 105	4 15 3	" "	..	..
180,227	10	4/6	Globe Telegraph and Trust	9⅝ 9⅞	9⅝ 9⅞	5 6 4	Jan., Apr., July, Oct.	9¾	9 11/16
180,042	10	6%	Do. 6 per Cent. Preference	14⅞ 15⅛	14⅞ 15⅛	3 19 4	" "	15	14 13/16
150,000	10	5/0	Great Northern	18¾ 19¼	18¾ 19¼	4 8 4	Jan., April, and July	..	..
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	104 107	104 107	4 13 6	March & September	..	..
17,000	25	37/6	Indo-European	41 43	41 43	5 15 3	May and November	42	..
38,348	10	5/0	London Platino-Brazilian	6½ 7⅛	6½ 7⅛	6 0 0	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	104 107	105 108	5 11 1	March & September	106½	..
9,000	8	4/0	Reuter's	8 8½	8 8½	4 14 1	April and October	..	..
3,381	£100 Cert.	£1	Submarine Cables Trust 6%	120 125	120 125	4 16 0	" "	..	..
15,609	10	6/0	West African Telegraph	8 9	8 9	5 11 1	January and July ..	..	..
£281,400	100	5%	Do. 5 per Cent. Debentures	96 99	96 99	5 1 0	March & September	..	..
30,000	10	2/0	West Coast of America	3⅞ 4¼	3⅞ 4¼	..	January and July ..	..	..
£150,000	100	8%	Do. Debentures 8% 1902	98 103	98 103	7 15 4	June and December	..	..
88,321	10	9d.	West India and Panama	1⅛ 1⅜	1⅛ 1⅜	..	..	1⅜	..
84,563	10	6%	Do. 6 per Cent. 1st Preference	9½ 10	9½ 10	6 0 0	May and November	9⅝	9⅜
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8 9	8 9	6 13 4	" "	..	..
61,683	15	9/0	Western and Brazilian	10⅜ 11½	10⅜ 11½	6 13 4	" "	11 1/16	10⅜
30,364	7½	1/6	Do 5 per Cent. Cumulative Preferred	6½ 7	6½ 7	5 7 3	—	6 11/16	6½
30,364	7½	7/6	Do. 5 per Cent. Deferred	4½ 5	4½ 4⅝	..	..	..	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	102 105	102 105	5 14 3	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	102 105	102 105	5 14 3	" "	104½	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	120 125	5 12 0	May and November	..	..
£173,100	£100	6%	Do, per Cent. Sterling Bonds	98 102	98 102	5 17 8	March & September	..	..
			TELEPHONES.						
224,850	14/0	0/5½	Consolidated Telephone Const. & Maintenance	7/16 9/16	7/16 9/16	..	May and November	—	—
220,000	£1	4·76d.	Oriental (11s. paid)	1/16 1/16	1/16 1/16	6 3 11	Yearly	..	..
438,984	5	3/6	National	4½ 4⅝	4⅝ 4⅝	6 9 9	June and December	4 1/16	4⅝
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½ 13	12½ 13	4 12 4	" "	12⅛	..
15,000	10	6%	Do 6 per Cent. Cumulative 2nd Pref. (£8 pd)	12½ 13	12½ 13	3 14 1	" "	12⅛	..
350,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd)	105 107	106 107	4 4 1	..	106⅛	106⅛
58,000	5	1/0	United River Plate	2 3	2 3	..	January and July ..	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85 95	85 96	5 5 8	—	..	..
			ELECTRICITY SUPPLY COMPANIES.						
1,000	£10	..	City of London Electric Lighting (£4 paid, £10 Sh.)	4 4½	..	..	—	..	..
19,900	£5	..	Electricity Supply Co. of Spain	.. ..	..	..	—	—	..
5,322	£5	..	House to House Electric	4⅜ 5⅛	..	..	—	..	..
30,000	£5	..	Liverpool Electric Supply (£3 paid)	4⅛ 5⅛	..	..	—	..	..
111,000	5	..	London Electric Supply	2⅜ 2⅝	..	..	—	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	10 10⅛	10 10⅛	..	..	10⅜	10 1/16
7,730	£5	3/6	St. James' and Pall Mall	7⅞ 8⅛	8 8⅛	..	..	8⅜	7⅞
..	..	7%	Do. 7% Preference	4⅜ 5⅛	4⅜ 5⅛	—	..	5	4⅜
42,853	5	..	Westminster Electric Supply (£5 paid)	5⅜ 6⅛	5⅜ 6⅜	..	..	6 1/16	5⅜
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978		..	Brush Electrical Engineering xd	3⅛ 3⅜	3⅛ 3⅛	5 3 0	..	3⅛	3⅛
69,996		6%	Do. 6 per Cent. Preference xd	1⅞ 2⅛	1⅞ 2	6 0 0	June and December	2 1/16	1⅞
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5 5½	5 5½	6 7 3	January and July ..	5 1/16	..
17,130	5	..	Edison and Swan United	.. ..	..	..	—	..	..
45,000	10	6%	Electric Construction	5⅞ 6⅛	6 6⅛	..	—	6⅛	6
70,000	2	10/0	Elmore's Patent Copper Depositing	3⅜ 4	3⅜ 4⅛	—	—	4	3 1/16
20,000	5	..	Fowler-Waring Cables (£4 paid)	2 3	2 3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	20 21	20 21	4 15 3	February & August	20⅜	20
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	104 106	102 104	4 6 7	March & September	..	..
11,334	£10	6/1	International Okonite Limited Ordinary	7⅛ 8⅛	7 8	..	..	..	..
11,334	£10	5/0	Do. Preference	9¼ 9½	9 9½	8 8 9	..	..	..
78,949	5	2/1½	Swan United (£3. 10s. paid)	5 5⅛	5 5½	6 7 5	May and November	5⅝	5 1/16
37,350	12	12/0	Telegraph Construction and Maintenance	42 44	42 44	5 9 3	March and July	43½	42½
50,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	102 105	102 105	4 15 3	January and July	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£2. 10s. paid)	2⅛ 2⅜	..	..	..	..	..
—	£5	..	Do. Preference (fully paid)	3¾ 4	..	..	..	..	—
			RAILWAYS.						
50,000	£10	..	City and South London Railway		4	—	—	—	—

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

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NOTES.

Mr. Denny Lane, the manager and secretary of the Cork Gas Company, is one of the few gas engineers who do not labour under the delusion that we are bitterly opposed to gas and everything connected with it. Where would electric light be if we had not begun by hundreds of small jobs run with gas engines? Where should we be without a little healthy opposition? Mr. Lane's article which we print in the present issue is worthy of the careful consideration of electrical engineers. At the first glance it seems to threaten an intrusion upon the work of electrical engineers; but if towns like Cork find that they can use electric light if distributed by means of their existing gas mains, so much the better for the electrical trade.

The method of measuring the heat developed by magnetic hysteresis, which is described by Prof. Ewing on p. 631 of the present issue, seems, as he says, to admit of no doubt. So long as this matter depended on complicated arrangements of dynamometers and other more or less accurate modes of determining the power given to and the power yielded by a transformer, it was generally felt that the quantity to be detected was hardly to be distinguished among errors of observation or of correction. But the simplicity of Prof. Ewing's method cannot fail to carry conviction of the results—when we get them. We were in error last week in saying that he has already employed it; for the coils are wound, but he has not yet experimented with them. The fact that the heat is generated in the one case by the current in exactly the same part of the transformer that is heated in the other case by hysteresis, is a great improvement over the method of warming one of the conductors, and the balancing can be checked by rearranging the connections of the two coils. We have received a letter from two correspondents who have studied the magnetism of iron with more care than they perused Prof. Ewing's article last week, and they draw attention to "a serious fallacy underlying Prof. Ewing's explanation;" but yesterday morning's post brought an urgent appeal that the communication might on no account be published, as there was a "nigger" in their argument.

It would be unfair to hold a man responsible for the utterances recorded in an interview, since the victims of this development of journalism are often more surprised than anyone else when they see the "interview" in print. But, however much the opinions of Mr. Massey may have been garbled by an evening paper last week, it is evident that he is but little satisfied with the present supply of electrical energy in London. He is reported to advocate "three big stations, each as large or larger than Deptford; one should be situated at the waterside, at, say, Bermondsey or Wapping, another near the water at Hammersmith, and the third somewhere in the neighbourhood of the Regent's Canal." It is not clear whether the existing stations are to be swept away, or whether they will be allowed to attempt to continue their work. The motive power for the Metropolitan and District Railways is to be thus supplied, among other things; and the main point of his remarks was that "in certain portions of London there is ten times the demand for power there is for light;" and he dwelt strongly on the advantages of doing away with boilers and machinery for printing. "Think of the hoists, lifts, ventilators, tramways, and a thousand and one things we could work by electricity, all part and parcel of one big scheme! These little bits of central stations over which so much fuss is now made are as nought to it." So far, the "scheme," if so it can be called, is interesting; but we fail to see where the economy is going to come in.

There are a few engineers, Mr. Ferranti being one of them, who hold that great economy can be obtained from large steam engines; and it is generally agreed that no appreciable advantage is to be obtained by building engines of greater power than about 300 H.P. It is manifest that no improvement is possible in dynamos as far as efficiency is concerned; and the question resolves itself into one of distribution and general expenses. Mr. Massey is reported as having remarked that Deptford "is said to have proved itself not exactly a success, but that is probably because there is a loss in the conversion of high into low tension currents by apparatus that is always at work, whether lighting is being done or not, and they have not attempted to supply power." This is news to us, for we thought that the chief trouble of the London Electric Supply Company was a lack of demand, and that this is largely due to the unfortunate fire at the Grosvenor Gallery, when old customers went over to other companies, and new ones were reluctant to come on for fear of more mishaps. This Company, moreover, is the only one which systematically uses sub-stations, and adapts the number of transformers in use to the load. It would appear that Mr. Massey advocates a low-pressure or a continuous current supply.

It appears that Mr. Massey thinks that the cost of these huge stations, of the distributing mains, and of the expenses

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of management will compare favourably, when reduced to the horse-power-hour delivered, with the rent and expenses of separate machinery. It would be very interesting to our readers to hear from him how this can be shown; we fail to see how it can hope to compete. The cost of a brake horse-power-hour to a large printing-house cannot differ very widely from that generated in a supply station; and yet it is out of this difference that the whole cost of distribution and management is to be paid, to say nothing of the losses of conversion in the dynamo and motor, for these are but trifling compared with the expenses which Mr. MASSEY overlooks. Some idea of this expense is to be gathered from the "little bits of central stations." They can generate an electrical unit for from 1d. to 1½d., and have to charge 7d. or 8d. for delivering it, and make no great profit at that. We are sure that Mr. MASSEY would not make rash and unconsidered statements, and we should be glad to hear how he supports those to which we have alluded.

ANOTHER instance of the neglect of interest on first cost is to be found in the rather roundabout way of lighting Edinburgh by electricity which has been suggested to the councillors of that city by Prof. G. FORBES. It has been proposed to generate steam by refuse destructor furnaces, and to pump water into reservoirs on Arthur's Seat or Calton Hill, and this would be used for driving turbines as occasion demanded. The *Scottish Leader* is very indignant at "the conversion of their historic and beautiful eminences into mere receptacles for bilge-water." We thought that this was no more than an off-hand suggestion, for the single merit that it offers is the small and indeed negative value of the fuel, Prof. FORBES being very fond of refuse destructors; but we learn from the *Edinburgh Evening News* that a conference of the members of the Town Council was convened at which the details were explained. If coal is worth 15s. a ton, and it costs 2s. 6d. a ton to get rid of refuse, the saving may no doubt be put at 17s. 6d. But the unfortunate element of first cost insists on intruding such schemes as this and that of Mr. MASSEY in the shape of interest and depreciation; and a very little figuring will show in this case, as in most tide-mill, windmill and many water-power schemes, that it is on the whole cheaper after all to put down an ordinary steam engine and burn coal than to buy refuse destructors, boilers, steam-pumps, water-mains, tanks excavated in the rock, turbines, and the necessary pipes and gear, with mains back to the town.

REPLIES to the criticism of a contemporary would be, as a rule, uninteresting to our readers, especially when the journal is one so little likely to be read by them as *Electricity* of Chicago. But, in the tenth number of the latest, but valuable, addition to American weeklies, our views are repeatedly and deliberately misrepresented. Our leading article of August 14th dealt with the question of exhibiting at the Chicago Exhibition; and we failed to find any reason why English manufacturers should take the trouble to send their goods so far when they are so plainly informed by the McKinley tariff that they are not wanted. We are, however, twice accused of having stated that Englishmen have nothing to learn in America. This accusation is easily refuted by turning to the article in question, which contains no such statement, but does contain the words, "There will be much to learn, and, perhaps, something to unlearn, and a harvest of knowledge will be reaped in a few hours, which, without the Exhibition, would require months of journeying in palace cars." This forms the theme of an article in our contemporary, and it is only with the desire to put ourselves right with our many American friends that we take any notice of it.

New Cable.—A submarine cable will shortly be laid between Pernambuco and Senegal. The project is promoted by an English company, and, unless unforeseen difficulties arise, within six months the line will be open.

Lahmeyer's Direct Current Transmission System.—We learn from the *Elektrotechnisches Echo* that the plant for transmitting power from Offenbach to the Frankfort Exhibition on Lahmeyer's continuous current system, which at first was working at 1,250 volts, has now for three weeks been working satisfactorily at a pressure of 2,000 volts.

Bray.—The principal streets of this town are to be lighted with arc lamps and the rest with incandescent, and the mains for the supply of current for private lighting will be laid at the same time. The electricity will be generated by water-power situated in the town. Direct current with motor transformers and storage batteries will be used. The contract was secured by Messrs. J. E. H. Gordon.

Electric Railway Concessions forfeited.—Mexican mail advices state that the Public Works Department has notified the forfeiture of a concession for an electric railway in Mexico City, granted to an American citizen. The concession has been cancelled owing to the required guaranteed deposit of $50,000 in Government Bonds not having been made by the concessionnaire in the time stipulated.

Inverness.—The committee of the Police Commissioners of the burgh of Inverness are gathering all the information possible with regard to the proposal to light Inverness by electricity. They agreed to recommend the appointment of Mr. Frederick Nell, hydraulic engineer, London, and Mr. James Fraser, Inverness, to prepare a joint report as to the water-power required for electrical purposes and the probable cost.

A New Use for Search Lights.—The gamekeepers on an estate near Bournemouth found that poachers were in the preserves, and by the aid of occasional flashes from the search lights at Hurst Castle they were able to recognise two men, who were subsequently arrested from the descriptions given by the keepers. Hurst Castle is, according to the *Daily Telegraph*, several miles distant from the place where the men were identified.

Train Lighting.—In reply to an enquiry, the General Manager of the London, Brighton, and South Coast Railway informs us that there is no truth in the report that the Company has decided to discontinue the electric lighting of their trains. They have some trains lighted by electricity, and the number may be slightly added to; but they cannot do much more, as most of their main line trains are divided at Croydon for Victoria and London Bridge, and in those they cannot economically use electricity. For all trains where they cannot use that mode of lighting they intend to use gas instead of oil, and perhaps this accounts for the report which has been circulated.

Swiss Telegraph Statistics.—The Swiss telegraph returns for 1890 show that the traffic remained practically stationary, the total number of telegrams of all sorts being 3,695,988, or an increase of only 2·03 per cent. In spite of the great development of inter-urban telephonic communication, however, the inland telegraph traffic has increased somewhat faster than the international and transit traffic, the augmentation being 2·79 per cent. With regard to foreign telegrams the total number ex-

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changed in 1890 amounted to 1,219,653, Germany taking 400,706, or 33 per cent., and France 378,201, or 31 per cent. During 1890 46·5 miles of new telegraph lines, comprising 82 miles of wire, have been erected; 209 miles of wire were also added to existing lines. The total length of line existing in Switzerland at the end of 1890 was 5,170 miles, of which 84 per cent. belonged to the State. There were 1,251 interruptions during the past year, of an average duration of 3·47 hours. Some 1,672 Morse and 41 Hughes apparatus are in use.

Mexican Telephone Company.—The Mexican *Two Republics*, of September 13th, says that the Mexican Telephone Company is about to undertake very extensive improvements and alterations in its plant, &c., in accordance with the terms of its concession. When the concession was granted, it was decided that after the Company had been in existence for a certain time (which has now nearly expired), it should adopt the cable system in place of the wire system now in use. At present, the Company has 850 wires, extending over 100 miles in length; and, while the long wooden poles are alleged to be unsightly, it is complained that the present system is liable to accidents and disarrangement. The Company has, therefore, decided to replace the existing poles and wires by cables containing 25 to 200 copper wires. This cable will be placed overhead and will be sustained by iron supports instead of the wooden poles now in use. The cost of replacing the old by the new system is estimated at $60,000, and the work will take about a year and a half to complete.

Conduits in Minneapolis.—The feeders of the Minneapolis Street Railway are buried underground in conduits which are built as follows:—Two-inch plank, first treated by boiling in fernoline, is used for constructing a long trough of the desired size. This trough is so nailed together as to be continuous and without joints from manhole to manhole, a distance of 408ft. The trough is placed below the surface at such a depth that the top is six inches below the paving blocks. The conduit proper consists of a number of heavy paper tubes of the Interior Conduit and Insulation Company's make. The tubes employed are 1in. and 1¼in. inside diameter, laid in the trough in 10ft. lengths and separated from each other and the sides and bottom of the trough by rings or spaces. The tubes are made continuous from manhole to manhole by use of a telescopic joint. After the tubes have been properly put in place, pitch is poured in, filling the interstices and leaving a series of highly insulated raceways with a solid insulated filling, impervious to moisture, around them. A large amount of this conduit has been in service since September, 1890, and has not as yet developed a single fault.

Reducing the Internal Wastes of the Steam Engine.—Some time ago, says *Industries*, we directed the attention of our readers to a proposal by Prof. Thurston for reducing the internal wastes of steam engines by reducing the heat-conductivity and the heat-storing power of the internal surfaces of steam-engine cylinders. The same thing had been attempted many times before, but without very much success. Prof. Thurston believed that he had discovered that it would be possible to form upon these surfaces a non-conducting stratum, integral with the material of which they were composed, with the metal of the cylinder itself, that should intercept the heat tending to pass away without transformation in any appreciable degree into work. This he had proposed to bring about, first, in any convenient and inexpensive way, effecting a partial solution of the superficial portion of the metal, leaving a spongy layer; then by the impregnation of this sponge with a resin or other non-conducting material produced by the painting of this surface with drying oil or with any available substance that should thus be found able to permeate and cling to the porous surface. Prof. Thurston's proposals were based only on laboratory experiments, but since they were made they have been tested on a larger scale, and he now thinks the matter fully settled.

New India-rubber Drying Processes.—In the September number of the *Bulletin Technologique de la Société des Anciens Élèves des Arts*, M. Ph. Rousseau publishes an interesting monograph on india-rubber. In the course of his remarks on the various methods of coagulation, M. Rousseau examines the chemical process recently introduced on a large scale by the Orinoco Company. This process merely consists in mixing the milk of the *hevea* with sulphuric acid and carbolic acid. Commercial sulphuric acid coagulates 55 times its volume of gum, and carbolic acid acts as an antiseptic to the coagulated juice, improving its keeping qualities. The chemical process of coagulation has the undoubted advantage over the method of smoking of diminishing the proportion of inferior rubber collected, the dust and vegetable dirt inherent to the old process being in a large measure avoided. The labour requisite is also less. Nevertheless, M. Rousseau is in doubt whether the rubber treated in this way will prove as elastic and acid-resisting as that coagulated by smoking. He argues that the molecular grouping of the rubber coagulated by the old Indian evaporative process, by the smoke of fires and by chemical action, is very different, and cannot but result in marked differences of physical and chemical properties. M. Rousseau is in favour of "barattage."

Continuous-Current Transformers.—Herr Lahmeyer, whose name is well known on the Continent as a dynamo designer, has, as was recently chronicled in these columns, severed his connection with the Deutsche Elektricitäts Werke of Aix-la-Chapelle, in order to devote himself to the development of a system of continuous-current transformer distribution. Temporary premises have been secured at Offenbach, pending the completion of a large factory at Frankfort-on-the-Main. According to *La Lumière Electrique*, Herr Lahmeyer proposes to build four-pole drum armature machines, the low-pressure conductors being placed in deep grooves cut in the periphery of the drum, and the high-pressure conductors being wound on the surface. The grooves are lined with vulcanised fibre, which projects above the top of the grooves, and helps to insulate the portions of the primary circuit from each other. The top of each groove is closed with a strip of iron sandwiched between two pieces of fibre. The system of distribution adopted by Herr Lahmeyer consists in continuous-current transformer sub-stations, the primaries of the transformers being supplied with current at about 1,000 volts pressure, and the secondaries feeding an ordinary low-pressure network at 100 volts. Herr Lahmeyer proposes to run powerful motors and arc lamps in series off the high-pressure mains. A 120 H.P. central station on this system will shortly be laid down at Brockenheim.

An American Water Power Station.—The new station of the Brush Company at Rochester on the Genesee River is a three-story stone building. The turbine capacity consists of 15 double 15-inch horizonal Lesner turbines under 90 foot head, with 14 foot draft tubes, a total of 3,360 H.P., using 6·95 cubic feet of water per minute per horse-power. The amount of floor space occupied by all of the turbines is 4ft. × 38ft. The weight of each turbine is 196 pounds, less than one pound to a horse-power. The dynamos are belted directly to the turbine shafting. The shafting runs at 800 revolutions per minute, with 25-inch pulleys on the turbine shafting and 24-inch on the dynamos. There are three iron penstocks 6ft. in diameter and 80ft. high, built of three-eighth inch boiler iron, with a gate to each penstock. There are five elbows to each penstock leading to as many turbines, with an iron slide gate to each elbow; in addition, each turbine has a register gate, thereby permitting the repairing of any one turbine without interfering with the running of the others. A turbine can be taken out and another put in its place in 25 minutes. There are three tail races extending under the entire length of the main building. As a reserve power, when making repairs and cleaning the race-way, there is a 600 H.P. Cooper Corliss engine; in the past year it has been necessary to use it but a few days. There are nine men employed at the station, five of them in the dynamo department and four in the water-power department. There are 30 dynamos; three of them are run without any stoppage, and the balance of them on an average of 13 hours per diem.

Mr. Ferranti and Niagara.—According to the *Street Railway News* of New York, Mr. A. P. Brayton, President of the Pelton Water Wheel Company, has just returned from a trip to Great Britain and Paris. Mr. Brayton met Mr. Ferranti, and refers to the latter's boldness in his plans and designs as unequalled. Mr. Ferranti has secured a concession from the Canadian Govern-

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ment to utilise the Canadian side of Niagara Falls for the purpose of the production of electrical power. The concession grants his company the privilege of using all the water it may need. It purposes taking the water from above the Falls and discharging it below, thus obtaining 140 to 150ft. fall. For this purpose Mr. Brayton can furnish a wheel capable of developing 5,000 H.P. if necessary. Mr. Ferranti expects to use dynamos of 2,500 H.P. capacity, and the Pelton Water Wheel Company will furnish wheels of 5,000 H.P.—two of 2,500 H.P. each, connected directly to the shaft of each dynamo. The works will start with a capacity of 20,000 H.P., necessitating the use of eight water-wheels. On asking for confirmation of this, we learn from Messrs. Ferranti, Limited, that the available fall is about 128 feet, and the proposed plant at starting is five dynamos, each of 1,500 E.H.P., and each driven by four small Pelton wheels mounted direct on the dynamo shaft. Probably for ultimate extensions dynamos larger than this will be wanted.

Manchester.—The arrangements for the installation of the electric light in the central portion of this city are now in a forward state, and the specifications will be prepared and the erection of the station and the laying down of the mains will be proceeded with without delay, the City Council having selected a site near Gloucester-street on Wednesday last. By the terms of their Provisional Order the Corporation are compelled to have the mains laid within the compulsory area before next August. In addition to electricity, hydraulic power will be transmitted, and, wherever possible, the hydraulic and electric mains will be laid together. One engine of about 400 horse-power, with a large dynamo, will generate at the station 250,000 watts, at a pressure of 400 volts. It is proposed to have three such sets of plant in the first instance, two working and one in reserve, and the building will be so arranged that the plant may be readily increased to a total of twelve sets. From the generating station the electricity will be conveyed on the five-wire system. Burnt in ordinary burners, as is usually the case, Manchester gas gives about 2½ candles per cubic foot per hour, whereas electricity takes about four watts to produce one candle. Hence, one cubic foot of gas per hour is equivalent to about 10 watts. To provide the compulsory area with electric light, machinery will be needed capable of delivering 900,000 watts, and to supply the whole area machinery capable of delivering 5,000,000 watts. It is proposed that the price shall be about 6d. per unit of 1,000 watts.

Steam Engine Efficiency.—Prof. Thurston contributed a valuable Paper, entitled "Steam Engine Efficiencies; the Ideal Engine compared with the Real Engine," to the recent meeting of the American Society of Mechanical Engineers. The ideal engine he defined as one having a non-conducting cylinder and frictionless rubbing parts. The real engine would approach this in proportion to the improved conditions of construction and operation. He thought wastes could be reduced "by drying or moderate superheating of the steam, and by adopting high speed of engine to one-half these proportions." It ought to prove practicable to bring the water consumption by the adoption of these high pressures, and by further dividing the wastes by the use of three or four cylinders in series, and by properly supplying dry steam to the engine, down to within 10 per cent. of the best figures here obtained for the ideal case. "The real measure of the useful power of an engine is not the indicated power, however, but the dynamometric power, as measured by the brake, or at the point at which the engine delivers its energy to the machinery of transmission. A well-built non-condensing engine should have an efficiency of machine at least as high as 92·5 per cent., and engines have been constructed doing better than this. An equally well-built condensing engine should approximate 90 per cent. efficiency of machine, though 85 is a much more common figure." The author then concluded: "It is apparently doubtful whether a vacuum will be found desirable, with its concomitant costs of the air-pump system, when we come to the utilisation of these high pressures; unless we can at the same time find a way to reduce the waste of power and the tax thus imposed upon the engine."

Gas Engines.—In a Paper recently read before the Société Technique du Gaz, the following remarks occur:—"The inventor turns his mind to the economy of fuel, which is of great but not of capital importance. Motors ought to be planned so that the ordinary workman can understand them, take them to pieces, clean them, and generally deal with them, without it being necessary to send for a person of special skill. Besides, gas engines do not work continuously; French statistics show that the average daily consumption of gas in gas engines is no more than 106 cubic feet per horse-power, and an extreme economy in gas is therefore practically of secondary importance. Lubrication, again, is of very great importance in the question of economical working. What good does a second cylinder or a very long cylinder do if its use involves a non-remunerative expenditure of oil? The mode of ignition is of importance. Flame ignition is incompatible with compressions beyond 2½ atmospheres; and the speed of travel of flame limits the speed of the machine, while the efficiency of the engine increases with the speed of the machine within certain limits. Electricity produces a small spark which may happen to go out in a poor stratum of gas or even in air or burned gas, and then the charge is lost. The best method appears to be ignition by incandescence; the incandescent mass does not go out suddenly, and a speed up to 500 explosions per minute has been attained under this method. The regulator ought to be very sensitive to the least variation of speed, for which purpose it ought to be light and to form an integral part of the machine, its movement being conveyed to it by rigid gearing, such as eccentrics, and it ought to be adjustable by hand while the machine is running. The piston should be of iron: steel cuts the cylinder too much; bronze is too soft and wears out, and it is often attacked by the oil. The horizontal shaft is often at fault in gas engines. The fly-wheel shaft, which is exposed to violent stresses, and has to support a heavy wheel, is often so badly supported that it bends and rapidly causes the wearing out of the bearings."

Differential and Integral Calculus.—A special course of evening instruction for beginners, on the differential and integral calculus and its application to the practical problems of mechanical and electrical engineering, will be given by Prof. John Perry at the Technical College, Finsbury, Leonard-street, City-road, E.C. A good working knowledge of the elementary principles of algebra and trigonometry is expected in students. Students who are unable or unwilling to devote at least two hours at home to working the exercises which will be set will not derive much benefit from this course of instruction. A lecture will be delivered every Tuesday evening from 7:30 to 9 p.m. commencing October 13th. The following syllabus is subject to alteration:—Oct. 13th: The uses to which a knowledge of the calculus may be put. The use of squared paper. One quantity a function of another. The notion of a differential coefficient; velocity; acceleration; electro-magnetic induction; self-induction; the study of a curve; examples. Oct. 20th: Fundamental rules of differentiation; examples in differentiation. Oct. 27: Examples in differentiation. Nov. 3rd: Ohm's law as extended to currents which are not constant. Alternating currents. How the practical rules employed by electricians are derived. Nov. 10th: Simple harmonic motion. Vibrating bodies. The compound-interest law in problems on belting, atmospheric pressure, electrical condensers discharging through great resistances, long pump rods. Vibratory motions which are damped. Hertzian vibrations. Nov. 17th: Conditions of maxima and minima examples. The strongest and stiffest beams cut from a tree. The most economical conductor for an electric current. Output from dynamo. Cut-off in steam-engine cylinder and other examples. Increased importance in engineering of this kind of calculation. Nov. 24th: The use of integration. Obtaining a list of simple integrals. The rules for integration. Examples. Dec. 1st: Finding the areas and length of curves, and areas and volumes of surfaces. Dec. 8th: Problems on steam and gas engine indicator diagrams and efficiency of engines. Dec. 15th: Further problems on areas and volumes and moments of inertia. Jan. 12th: The stiffness and strength of loaded beams. Jan. 19th: The use of Fourier's theorem. The electric dynamometer illustration. The effect of self-induction.

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THE DETERMINATION OF CURRENTS IN ABSOLUTE ELECTRO-MAGNETIC MEASURE.

BY G. F. C. SEARLE, M.A.

(*Continued from page 576.*)

§ 18. Magnetic Potential of a Small Magnet at a distant Point.—Let O (Fig. 18) be the centre of the magnet A B, A its north pole, m the strength of each pole, $2l$ its length, $M = 2ml$ its magnetic moment, P the point at which the potential is to be found, $OP = r$, angle $POA = \theta$. Draw AK perpendicular to OP, then $OK = l\cos\theta$, and since OP, AP are very nearly parallel $AP = r - l\cos\theta$, and similarly $BP = r + l\cos\theta$. Hence the potential of the magnet, which is the sum of the potentials of the two poles, is—

$$V = \frac{m}{AP} - \frac{m}{BP} = \frac{m}{r - l\cos\theta} - \frac{m}{r + l\cos\theta} = \frac{2ml\cos\theta}{r^2 - l^2\cos^2\theta}$$

Now, we are considering the case in which r is very large compared with l, we may therefore neglect l^2 in comparison with r^2 and write $V = \frac{2ml\cos\theta}{r^2} = \frac{M\cos\theta}{r^2}$

Our expression for the magnetic force in terms of the magnetic potential enables us to write down at once the magnetic force at P along and perpendicular to OP. We saw (§ 13) that $F = -dV/dS$, where F is the magnetic force along S in the direction in which S increases. If F_r is the magnetic force at P in the direction OP, then $F_r = -\frac{dV}{dr} = \frac{2M\cos\theta}{r^3}$. In finding F_θ the magnetic force at P perpendicular to OP in the direction in which θ increases, we must put $r\,d\theta$ for dS, and thus obtain

$$F_\theta = -\frac{dV}{r\,d\theta} = \frac{M\sin\theta}{r^3}$$

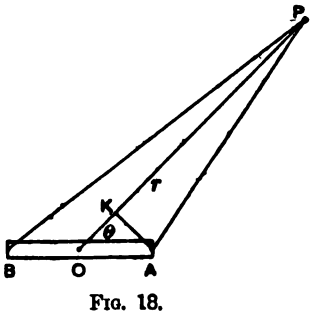

FIG. 18.

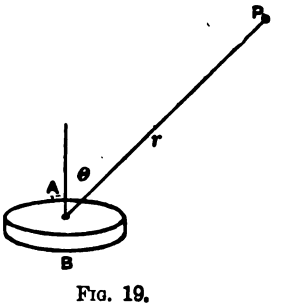

FIG. 19.

§ 19. We are now in a position to investigate the magnetic potential of a *magnetic shell*. Imagine a sheet of steel magnetised so that the whole of one side is North and the whole of the other South. If such a sheet can be imagined to become indefinitely thin, and at the same time to remain magnetised, it will constitute a magnetic shell. The strength of a magnetic shell is the magnetic moment of a square centimetre of the shell. We shall denote the strength of the shell by i. Let A B (Fig. 19) be a small portion of the shell, A being the North side, and its area being a. The portion A B constitutes a small magnet of magnetic moment ia. Let P be the point at which we wish to find the potential, and let $AP = r$ make an angle θ with the normal BA. By the last paragraph the magnetic potential at P is $v = ia\cos\theta/r^2$. But we have seen (§ 8) that $a\cos\theta/r^2 =$ solid angle subtended by the area a at P. Let this solid angle be denoted by ω. Then $v = i\omega$. The solid angle is positive when the North side of the portion is towards P. If the shell is uniform, and of any size or shape whatever, so that it subtends a solid angle Ω at P, then, by adding the potentials of all the elementary portions, we find for the potential due to the whole shell $V = i\Omega$. Now the solid angle subtended by the shell at P, and, therefore, its magnetic potential at P, depends only upon the boundary or edge of the shell, and not otherwise upon the shape of the shell. As long as the boundary remains the same we may fill it up with a magnetic shell of any form without producing any change in the potential due to it. The fact that the potential of a magnetic shell of given strength depends only upon the shape of its edge is exceedingly curious; it is of fundamental importance in the theory of electro-dynamics.

A very important result is easily obtained. Let the curve A B (Fig. 20) represent any section of a magnetic shell, A and B being points on the edge. Let P, Q be two points very close together, one on each side of the shell, the side of the shell next to P being the North side. We wish to find the work which must be done in taking a unit magnetic pole from P to Q, or in other words the difference of potential between P and Q. Let P describe the path $P P_1 P_2 P_3 Q$, which does not cut through the shell. The magnetic potential at P is $i \times$ (solid angle A P B). Describe a sphere of radius 1 cm. about P; the solid angle at P is measured by the area in square cms. of this sphere intercepted by the cone A P B. As P moves let it carry the unit sphere with it, and let us attend to the changes of the area on the sphere intercepted by the cone A P B. When P has moved to P_1 this area has diminished, and at some point between P_1 and P_2 will vanish; at P_2 the South side is turned towards P, so that the solid angle must now be reckoned negative. This solid angle gradually increases negatively, until, when the point has arrived at Q, it has the value $-(4\pi - A Q B)$. But since P and Q are indefinitely close together, the solid angles A P B and A Q B are indefinitely nearly equal. Thus the increase of magnetic potential in going from P to Q is $i\{-(4\pi - A Q B) - A P B\} = -4\pi i$. Hence we find that, whatever the shape of the magnetic shell, and whatever the form of the path along which we take the unit pole, we expend $-4\pi i$ ergs of work in taking the pole from a point very close to the North side of the shell to a point very close to the South side. If we take the pole from the South side to the North side, we do $4\pi i$ ergs of work. But if we make the path $P P_1 P_2 P_3 Q$ such that P and Q have no part of the magnetic shell between them, then it is easily seen that the whole change of solid angle in passing from P to Q is zero when P and Q are indefinitely close

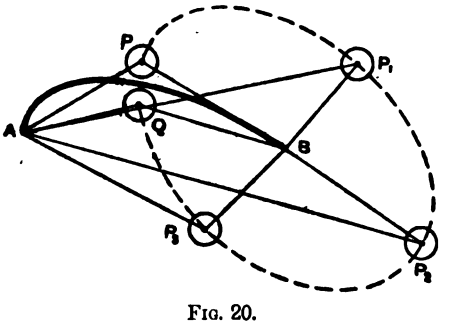

FIG. 20.

together. Thus, in this case, on the whole no work is done in taking the unit pole from P to Q.

If, in the first case, we make a very small perforation through the shell, and make the pole return absolutely to P again, then we can easily show that we must expend $4\pi i$ ergs upon it in bringing it from Q to P. Thus, when the path is absolutely complete, the total work done is zero. Any other result would be at variance with the law of the conservation of energy.

§ 20. We can give another interpretation of the expression $V = i\Omega$ for the magnetic potential due to the shell. If we bring up a pole of strength m, from a great distance to any point P, near the magnetic shell, the work spent upon it is $mi\Omega$, Ω being positive when the north side of the shell is seen from P. But $m\Omega$ (*see* § 11) is the number of lines (or tubes) of induction which would pass from m through the boundary of the shell if the shell were not magnetic. Thus the mutual potential energy of the pole and shell = strength of shell × number of lines of induction, which would pass from m through the boundary of the shell, if it were non-magnetic, in the opposite direction to those actually proceeding from the shell. If, instead of a single magnetic pole, we have any magnetic system, we can decompose it into a number of magnetic poles. The potential energy of each of these due to the presence of the shell is proportional to the number of lines of induction it would send through the edge of the shell if the shell were non-

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magnetic. By the principle of the superposition of magnetic fields (*see* § 12) we see* that the whole number of lines through the edge due to the magnetic system is the sum of those due to each separate pole, of which it may be considered to be made up. Thus the mutual potential energy of any magnetic system and any magnetic shell is equal to the product of the strength of the shell by the number of lines of induction due to the magnetic system which would pass through the boundary of the shell, if it were non-magnetic, in the opposite direction to those actually due to the shell itself. Since lines (or tubes) of induction are always closed upon themselves, the only way in which a line which was not passing through the boundary of the shell can pass through it is by having cut

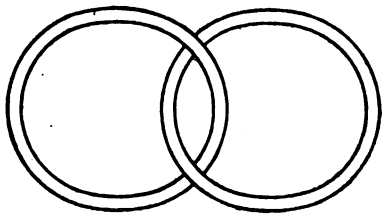

FIG. 21.

through the boundary. When a line of induction passes through the boundary of the shell, we may say that it is linked with the edge of the shell. We have thus been led to perceive that every additional line or tube of induction which is linked with the edge of a shell of strength i has involved the expenditure of i ergs of work if the line passes in the opposite direction to those due to the shell. We shall return later to some considerations about this linking.

(To be continued.)

DISTRIBUTION OF ENERGY BY GAS.

BY DENNY LANE.

There was a time when the proprietors of gasworks were so much alarmed by the advent of the electric light that they parted with their shares at a heavy loss. Experience has proved that their fears were ungrounded, and, in fact, the consumption of gas has increased more rapidly in the last decade than it had in any previous period. The very stir that was caused by the threatened competition roused the energies of gas engineers, who were waxing fat, and perhaps growing lazy, after many years of unbroken prosperity. I always alleged that the electric light would never injure the shareholders in gas companies. On the contrary, it has conferred benefits on them, which may, in my opinion, be considerably increased. As I have devoted a good deal of time and thought to the connection between gas and electricity, I will endeavour to point out a mode by which each may be made to help the other. A celebrated old theological treatise is called "*Concordantia Discordantium Canonum.*" In the same spirit I would wish to evoke harmony out of the discord which is supposed to exist between those two brilliant rivals.

The subject naturally divides itself into three heads: the generation, the storage, and the distribution of the agents to be employed.

With respect to generation of illuminating gas, there is not much hope for any substantial improvement. The practice of three quarters of a century has naturally developed highly an industry which yields residuals that return a large proportion of the first cost of raw material. I believe that the cost of labour in gas making will certainly be reduced to the extent of two or three pence per 1,000 cubic feet, but beyond this I see no probability of further economy. With reference to heating gas, it is, however, a different question; I believe such gas can be produced at a price lower than that of 16-candle gas, but, of course, would require separate mains.

With respect to the generation of electricity from motive power we cannot hope for any improvement. With the many admirable dynamos of all kinds which are now procurable, it is a proud thing for electricians to say that they have left no room for improvement. When dynamos convert 90 to 95 per cent. of mechanical into electrical energy, they have far exceeded the results obtained in every other analogous transformation, and by so doing have endowed their favourite science with one of the brightest of the jewels that adorn her crown.

Next, as to storage. The gas engineers have this immense advantage that their hourly production need not be more than the *average* demand of 24 hours of mid-winter, while the electrician, who does not use storage cells, must have producing power sufficient to meet the heaviest hour, or, in fact, *minute* in the year, although that may require five or perhaps ten times the average consumption. On the other hand, if he employs accumulators, he has to meet a heavy first cost and a depreciation which, with a fair interest on capital, will run up to 15 or 20 per cent. per annum. Nevertheless, I believe that for those hours (and in summer they are long ones) in which the demand for light is low, great economy will result from the partial employment of these most useful garners of energy.

The third point to be looked into is distribution; and when I first worked out the problem I own I was surprised at the low cost of the distribution by means of gas supplied to gas engines. My surprise was increased and confirmed lately on reading the excellent lectures which Mr. Kapp has delivered on the transmission of energy. I saw more clearly than before the great losses incurred by the transfer of energy in every other case, except that furnished by gas mains. In many cases the existing mains are capable of transmitting as much gas as would in all probability be required for electric lighting at present prices. I think it fairer, however, to calculate what would be the expense of separate mains laid to supply electric sub-stations I do so for four reasons:—

1. Because this gives the total cost of distribution.

2. Because it gives an opportunity of supplying cheap gas of good heating, but low illuminating power, which might also be used for stoves and cooking.

3. Because it affords the means of increasing the supply of gas as the demand for electricity increases, without throwing undue pressure on the service pipes of ordinary consumers.

4. Because the unaccounted for gas would be very small. In fact, gas companies get paid for what is delivered at the consumer's meter, a quantity considerably less than that supplied at the inlet of the distributing mains. But the loss can easily be accounted for by minute leakages in the innumerable joints of the service pipes and connections to the meter—each small in itself, but, when multiplied by myriads, making up an important aggregate. With a good main, carefully laid, and not tapped for services, the leakage would be small, and should not amount to 1 per cent. of the quantity delivered. In such a case the pressure can be increased considerably without causing any notable loss, or any inconvenience to ordinary consumers.

Of course, gas will not travel through a main without some propelling force, but the amount required is extremely small, as may be judged from the following example. As water weighs about 62½lbs. per cubic foot, the weight of a column of water of 1ft. area and 4in. deep is under 21lbs. This gives what is called "four inches pressure." In a good gas engine the consumption of gas should not be more than 24 cubic feet per brake horse-power when at full work; but I will allow one-fourth more, thus making a more than ample provision for the extra proportion of friction, which exists when the engine is not working up to its full capacity. We therefore have for the power employed to force enough of gas through the mains for one horse power $30 \times 21 = 630$ foot pounds. As a horse power for one hour means $(33{,}000 \times 60 =)$ 1,980,000 foot pounds, our

* We can make this clearer as follows:—Let a be a small area on the shell. Let $f_1, f_2 \ldots\ldots$ be the magnetic forces at the centre of a due to the poles $m_1, m_2 \ldots\ldots$, and let $f_1, f_2 \ldots\ldots$ make angles $\theta_1, \theta_2 \ldots\ldots$ with the normal to a. The number of lines of induction through a, if m_1 is the only pole in the field, is easily seen to be $f_1 \times a \cos\theta_1$ and so on for the other poles. The sum of all these quantities is $a \times \Sigma f \cos\theta$. But $\Sigma f \cos\theta$ is the resultant magnetic force at right angles to the shell and, therefore, $a.\Sigma f \cos\theta$ is the number of lines of induction through a. From this the statement in the text follows at once.

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propelling power is only 1,980,000 ÷ 630, or the $\frac{1}{3145}$ part of a horse power. In other words, 1 H.P. employed at works would force through the mains as much gas as would supply over 3,000 H.P., at 4in. difference of pressure.

Of course, the quantity of gas that can be sent through a main depends on the size of the main and on its length, varying in practice directly as the square of the diameter, and inversely as the square root of the length. But I will give a practical example; taking my figures from Barlow's Tables, I find that a 6in. main one mile long will deliver 9,000 cubic feet of gas per hour at the difference of pressure of 4in., which I have given above; and if we divide this by 30 cubic feet, we get 300 H.P. delivered at this moderate difference of pressure.

Let us see now what the cost of such a main would be. At £5 a ton (in many places the price is less), a 6in. main costs 4s. a yard or £352 a mile. If with turned and bored joints, the cost of laying would be 1s. 6d. a yard in a paved road, or £132, making in all £486, let us say £500, a mile. The interest on this at five per cent. would be £25, or 1s. 8d. per H.P. per annum. If, however, the pressure was increased to 16in., double the quantity would be delivered, while the motive power absorbed would be considerably under 1 H.P. at the time of the maximum delivery of 600 H.P. for one mile. I believe no other instance can be given of so moderate a cost for the transference of energy.

Counting the cost of gas at 2s. 6d. we have in the first case 300 H.P. transferred one mile by the expenditure of 300/3,000, equal one-tenth of a horse-power or one-tenth of a penny. In the second case we have 600 H.P. carried a mile at a cost less than one halfpenny. But besides this remarkable economy, we have also the following advantages. The cartage of coal to and of ashes from a station is done away with. No nuisance is caused by the escape of smoke or of steam, and, if the foundations are properly arranged, and the base of the engines isolated from the surface of the ground, no damage will be caused by vibration. The whole space occupied by boilers will be saved, and where space is of value a building of three floors—the two lower containing gas engines and dynamos, and the upper storey giving room for attendants and regulating gear—can be employed.

But, again, a most important saving would be made in attendance. Practically a good gas engine requires no continuous attendance. A daily supply of oil and an inspection which need occupy only a quarter of an hour is all that is necessary. I can say this from several years' experience. Formerly there was some difficulty in starting gas engines. Now several contrivances enable this to be effected without any trouble.

Again, the wear and tear of gas engines is extremely small. At works here a small engine has run for over 36,000 hours; at the end of that time it required a new lining to the cylinder, which cost 2½ per cent. of the first cost of the engine. The slide valve required to be scraped occasionally, but the slide valve has been dispensed with in engines of modern make. This engine, although working continuously night and day, is looked to only twice in the 24 hours, in order to give a supply of oil, and take the index of the meter. It is working in a yard where it is exposed to some extent to the dust of coke, one of the most active grinding materials we know, and but for this it is probable the cylinder lining would have lasted longer. Now, if a station is supplied with a small proportion of storage cells, I think I may assume that the dynamos will not be required for more than five hours a day on an average, say 1,800 hours a year. If my data, therefore, be correct, a gas engine should work for 20 years, and then may require a new cylinder lining, which would come to 2½ per cent. of the first cost. To this must be added the insignificant cost of new piston rings required occasionally.*

Compare this with the wear, tear, and maintenance of steam engines, remember the wages of stokers and engineers, and I think a remarkable economy in the up-keep and attendance of the gas-motor must be admitted. Again, with the best boilers, it takes a considerable time to get up steam, and in work necessarily intermittent the heat accumulated in the boiler and setting is wasted. We are thus burning the candle at both ends *without deriving any light* from it. It is this cause which runs up the cost of coal for electric light stations so very high. Dr. Fleming estimates it at from 9 to 22lbs. per unit sold. In one case in the North of England I find the consumption is 23·4lbs. per unit.

On the other hand, a gas engine can be started in less than a quarter of a minute; as soon as it is stopped all consumption of fuel ceases. Hence its great economy whenever the demand for power is intermittent. Next as to the chance of break-down or interruption. The steam engine and boiler form a very complex arrangement. If any serious injury to any of the essential parts takes place, the whole system is made inoperative, and in most cases the boiler must be stopped occasionally for cleaning, examination and repairs. On the contrary, the gas engine is extremely simple in construction.

Of course, "accidents will happen in a family as well regulated" as that of the gas engines, but fortunately these are very rare. I will conclude by giving a singular example. At a large printing establishment in Cork, a gas engine worked very irregularly, and finally struck work. Messengers were sent to complain "that the gas was bad," "that there was no pressure," "that the meter was out of order," "that the service was choked"—in fact, the whole litany of complaints was recited. One of our engineers immediately attended, and found nothing wrong with the supply, or apparently with the engine, which, however, refused "to do a stroke of work." On examination he found that the supply of air to the engine was derived from a pipe which was carried up outside the building to a height of about 8 feet; the object of this arrangement being to take air at a high level, and so avoid dust, &c., which might be drawn in and injure the cylinder, piston and valves. This air inlet pipe was found to be choked, and what, think you, was the nature of the obstruction? It was composed of *thirteen boys' caps*. In fact, there is a school close by, and the Cork boy, being of a scientific, ingenious, and inquiring disposition, noticed that there was a considerable indraught at each inspiration of the engine, and having being taught that "Nature abhorred a vacuum," he endeavoured to secure a "plenum" by tossing another boy's cap close to the end of the pipe, where it performed the pleasing conjuror's trick of suddenly vanishing. Of course the other boy returned the compliment; and so it went on, and would have gone on, until all the caps of the school were absorbed, were it not that the air fiend got so gorged that he lost all appetite, and "died of shortness of breath."

You will, of course, notice that I have said nothing of the cost of gas used in gas motors; but as this communication is already too long, I will, with your permission, reserve my remarks on this subject for another occasion. I have only dealt with the distribution through feeders. The present practice seems to depend on distributing from sub-stations at a low pressure, whether the alternate or the continuous current be employed. Of course, the system I advocate dispenses with banked transformers, and would probably use storage cells for a certain portion of the delivery, although equally well adapted for the alternating current.

* I have just heard of a case where a gas engine has been running 168 hours a week for 11 years, without any renewal of cylinder lining or of piston. The last piston rings were put in three years ago.

Celluloid.—In view of the tendency to employ celluloid for several electrical purposes the following particulars may be of interest. Celluloid is simply made up of nitrocellulose, camphor, and water. It was invented in 1869 in America. In 1876 the industry was introduced into France. Germany also possesses two large factories, whilst the largest in the world is in London. Crude celluloid is a horn-like transparent mass of a slightly yellowish colour, and of specific gravity 1·25-1·45. Heat softens it and renders it capable of taking impressions. At 90 deg. it becomes very plastic. It readily kindles. Sulphuric acid rapidly decomposes celluloid on heating, whilst hydrochloric acid attacks it much less vigorously. Nitric acid slowly attacks it in the cold, very rapidly on heating, and the same is true of caustic soda. Acetic acid dissolves it, giving a solution from which water precipitates camphor and nitrocellulose; it is also soluble in ether, acetic ether, acetone, fatty oils, alcohol, and turpentine.

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The Electrician.

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REPORTING THE DEBATES OF SCIENTIFIC SOCIETIES.

At a recent meeting of the Société Internationale des Électriciens an enterprising member, M. J. A. MONTPELLIER, proposed that stenographers should be admitted at the monthly gatherings of the Society, in order that a *compte rendu intégral* might be taken of the proceedings. Such a course seemed to M. MONTPELLIER to possess many advantages, and he cited the example of several similar institutions in his support. The President, M. JOUBERT, was, however, of opinion that there was but little to be gained by preserving what he called the "physiognomy" of scientific discussions, where the bases upon which the paper superstructures were reared were not likely to be upset in the course of casual controversy. M. MASCART supported this contention, and the proposal was thereupon politely referred to a Committee, to be heard of no more.

With us in England there is the usual characteristic diversity of practice. Each society does what seems good in its own eyes, without as a rule troubling itself about the mode of procedure adopted by its neighbours. The whole gamut between the rigid secrecy of the Institution of Civil Engineers and the unqualified publicity of the various gas associations is played. One institution, with the desire, we believe, to afford its members the fullest opportunity for revising their remarks, postpones any publication whatever for many months. Another welcomes the reporter, technical or otherwise; in some cases, indeed, the non-technical stenographer is rather preferred, being more likely to take copious notes of the commonplace generalities of the eminent advertiser, and to "cut down" to a minimum the more abstruse remarks of the modest investigator. Other learned bodies act on the principle of here a little and there a little; they adopt one rule from this society and another from that, and are thus in

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a position to defy the criticism of all those who respect precedents. The general tendency of such a policy is, however, to limit the sphere of usefulness of those who pursue it; they become enamoured of their precedents and fail to see that a new science may be none the worse for a little initiative. The principle is, indeed, an excellent one, but only on the assumption that what is intrinsically good is imitated, and that which merely possesses the prestige of long use is critically examined and, maybe, rejected. The aversion of corporate bodies, whether scientific or other, to the publication of their proceedings has, we suppose, for its ultimate root the natural antipathy of every individual member for anything approaching publicity in connection with his own private affairs, although we need hardly point out that the two things are not exactly on all fours. There are, however, but few who would in these days be bold enough to openly argue in support of the thesis that scientific societies exist for the delectation of those who have the good fortune to be able to attend their meetings or who possess the pecuniary means to purchase their often expensive journals. The reasons alleged for the exclusion of reporters are, therefore, usually that verbatim reporting and prompt publication in the technical press tend to promote prolixity and playing to the gallery. Now, verbosity and advertising are certainly to be deprecated, and especially so in the discussions of scientists and engineers. But while granting this much, it does not follow that one must admit the premiss.

It is now more than two years since the Council of the Institution of Electrical Engineers after due deliberation came to the conclusion that the welfare and dignity of the Institution required the exclusion of reporters from its debates; yet we have not observed any marked diminution in the average length of the speeches, on the contrary we can call to mind several instances of inconvenient prolixity, and one or two amusing attempts at advertisement. The precautions which were taken in the early part of 1889 do not, therefore, appear to have been entirely successful in effecting a cure. The question may well be asked whether the disease is not inherent to our fallen state, and whether a milder remedy would not prove just as efficacious without entailing any undesirable consequences. One result of the system at present in vogue is that many who are interested in electricity both on its practical side and from the point of view of pure science are to all intents and purposes excluded from participating in the benefits to be derived from learning what is thought on matters of current interest by those best qualified to offer an opinion. The Institution of Electrical Engineers, notwithstanding the powerful traditions of the *doyen* of engineering societies, has already done well in permitting the prompt publication in full of all Papers read before it. Why not do better still, and revert to the old system of allowing its debates to be equally promptly and fully reported? To exorcise the evil spirit of prolixity the ten minutes' rule might well be made automatic and inexorable. It is surprising what a vast amount of valuable information it is possible to impart in ten minutes, after a little practice; if a speaker has previously made up his mind what he intends to say and how he means to say it, something like one thousand words can be easily emitted in that brief period of time. In parliamentary debates attempts at eloquence, and in scientific discussions attempts to speak without due preparation, are responsible for the major portion of the time that is wasted. Whenever a speaker rises at the Institution of Electrical Engineers the President might start a time-glass, which, when run out would ring a bell, and after this peremptory summons everyone would have to throw himself on the mercy of the meeting, while members dropping into the anecdotal vein or persistently wandering away from the subject under discussion into "green fields and pastures new," might perhaps be more sternly brought back to the point than has hitherto been customary.

With these innovations, and with all Papers printed and in the hands of members well before each meeting, the arguments against the admission of technical reporters would lose what little force they may once have had. Indeed, a return to the old order of things would, under the circumstances, prove the reverse of harmful. With the speakers in full possession of the facts there would be less excuse for straying from the point, and when ample time has been given for the detection of erroneous statements, their demolition within the allotted period of ten minutes ought not to be impossible. The discussions might be expected to gain in utility, and the individual speeches in conciseness. The statements of the readers of Papers and the counter-statements of those holding contrary opinions would appear side by side, a desideratum which the authorised abstracts, promptly and well done as they are, cannot be held to adequately fulfil. Abstracts can at the best only give the barebones of a debate.

A METHOD OF MEASURING THE HEAT DEVELOPED ON ACCOUNT OF MAGNETIC HYSTERESIS IN THE CORE OF A TRANSFORMER.

BY PROF. J. A. EWING, F.R.S.

I have arranged the following apparatus to measure the heating effect of magnetic reversals in the core of a transformer under various conditions as to frequency, intensity of magnetisation, and load (that is, output on the part of the secondary coil). The experiments are specially intended to test, in a manner which will admit of no doubt, whether the loss of energy that occurs through magnetic hysteresis is less, per cycle, when the transformer is loaded than when the secondary coil is open or is closed through a high resistance.*

A small transformer is wound, the core of which consists of an "anchor-ring" of soft iron wire, cotton covered so that the turns of the core are completely insulated from one another. Over this a primary is wound in two layers, uniformly distributed round the whole circumference of the ring. Over this, again, a secondary is wound, also in two layers, and uniformly distributed. Before winding the primary and secondary, a thermo-electric junction is imbedded in the insulated core. To avoid circumlocution, we shall call this transformer A.

A second coil, B, is then wound, which has the same dimensions and number of turns as A in its core, its primary, and its secondary, and is exactly like A in every respect, except this—that the two layers of the "primary" in B are joined so as to oppose one another, and therefore to produce no magnetising effect on the core, and the two layers of the "secondary" in B are also joined so as to oppose one another. Any current passing through either the "primary" or the "secondary" of B exerts no magnetic force on the core. A thermo-electric junction, a duplicate of the one in A, is imbedded in the core of B.

The two coils are now connected with the primary of A in series with that of B, and the secondary of A in series with that of B, with an alternator in the primary circuit and an adjustable resistance (to vary the output) in the secondary circuit. The thermo-electric junctions are connected so as to oppose each other; and a galvanometer, put in circuit with them, serves to detect any difference of temperature which may come to be developed between the two cores.

When alternating currents are sent through the primary of A, inducing secondary currrents, and making it act as a transformer, its core suffers reversals of magnetism, the heating

* See *The Electrician*, October 2, 1891, p. 597 and p. 602.

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effect of which we wish to measure; but though the same currents traverse the primary and secondary of B, the core of B remains inactive. The Joule effect, due to both primary and secondary currents, is precisely the same in both A and B. The difference of core temperature, which soon shows itself in the thermo-electric circuit, is therefore due to the heating effect of hysteresis alone.

Finally, I balance this heating effect by passing a continuous current through the insulated iron core of B, adjusting the strength of the current until the core of B is heated by this current at just the same rate as the core of A is heated by the reversals of magnetism which are going with uniform frequency in it. The adjustment is correct when there is no progressively increasing deflection of the galvanometer in the thermo-electric circuit.

Knowing the strength at which the steady current has to be maintained to keep up this balance, and the resistance of the iron core, we find the energy expended by it in the core of B, which is equal to the energy lost by magnetic reversals in the core of A.

THE FRANKFORT EXHIBITION.—XII.

(FROM OUR SPECIAL CORRESPONDENT.)

Kummer's dynamometer, of which we give some illustrations, is a convenient instrument for measuring the power supplied by an engine when it is possible to connect the driving engine with the driven machine by means of belting, in such a way that one belt runs from the driving engine to one pulley of the dynamometer and another from the other pulley of the dynamometer to the machine driven. The dynamometer is thus the connecting link between the two beltings, and measures the power transferred from the one to the other.

The following is a short description of the mechanism and the mode of measuring.

Figs. 1 and 2 show the machine in perspective, Fig. 2 showing it with one of the pulleys removed.

Figs. 3, 4, and 5 show the mechanism more clearly. It will be seen that the axis a' which lies in the bearings in o, o', carries three arms d, d' and e; the first of these, d, (Figs. 3 and 5) has bearings at its ends for an axis i, which is parallel to it and which (Fig. 5) carries at its lower end the lever g. This is provided at q' with a long slit, into which fits one end of the double lever ff'; this lever is capable of turning on the pivot w, which is fixed on the extremity of the arm e.

The axis i is provided at its upper extremity with the double lever $k\,k'$, (Fig. 4) whose extremities fit into the two projections, $n\,n'$, $v\,v'$ of the pulleys c c', and it is this lever which transfers the power from the one pulley to the other.

The inner extremity of the lever ff' (Fig. 5) is in close contact with the rod b (Fig. 3), which fits loosely into a hole in the axis a, and rests with its outer extremity in contact with the pointer r. The arm d' is simply to keep the centre of gravity of the system in the diameter of the axis; and for small adjustments the moveable weight e' is screwed on.

The pointer r is pressed forcibly against the rod b by means of the constant weight u acting at various positions of the lever arm r' (Figs. 3 and 4) or a variable weight in a scale, which is the method most recently employed (Figs. 1 and 2).

The dynamometer works in the following manner.

The belting from the driving machine is placed on c, and that to the driven machine on c'; the power from the first pulley c is consequently transferred to c', and c' tends to lag behind c, a wrench being brought into play between the two, which is transferred to one between the two ends of the double lever $r\,r'$ by means of lever $k\,k'$, axis i, lever g, double lever ff' and rod b.

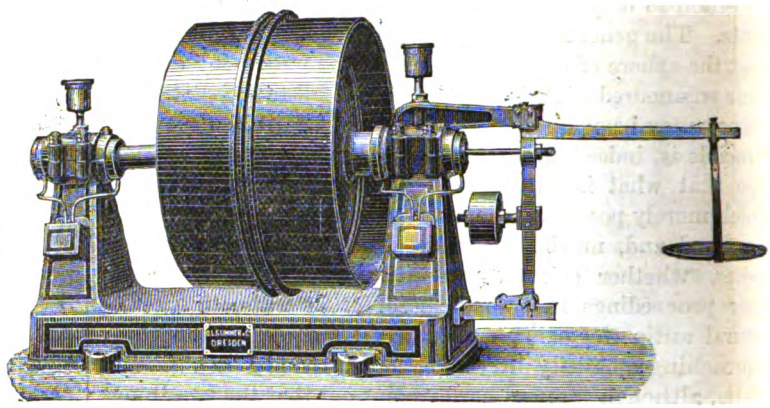

FIG. 1.—Kummer's Transmission Dynamometer.

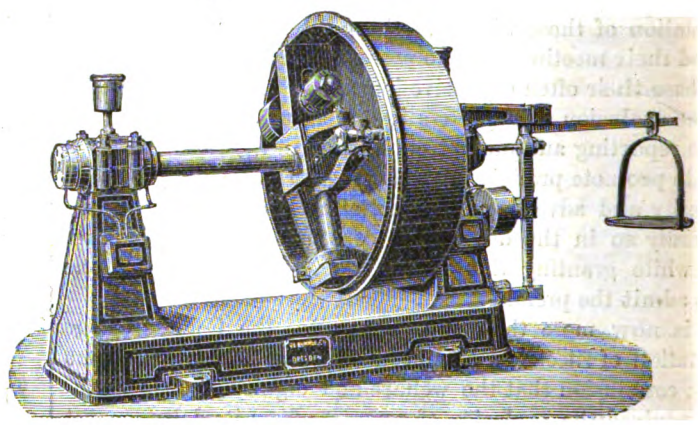

FIG. 2.—Dynamometer showing Driven Pulley removed.

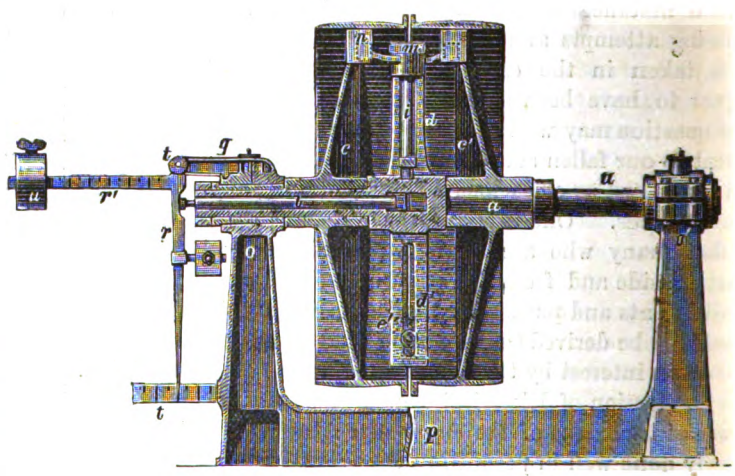

FIG. 3.—Sectional Elevation, longitudinal.

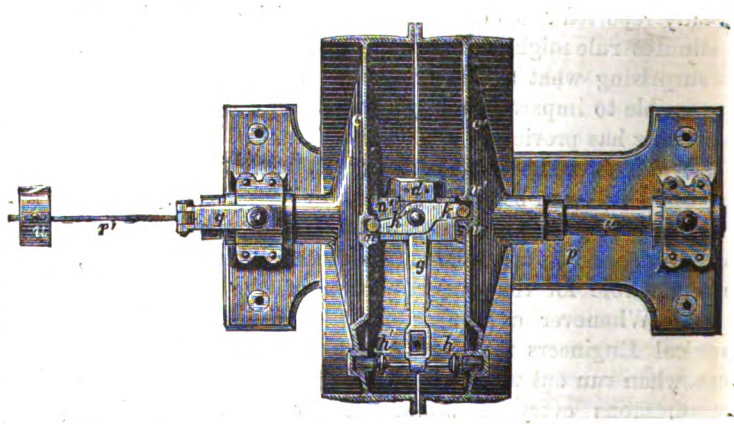

FIG. 4.—Sectional Plan.

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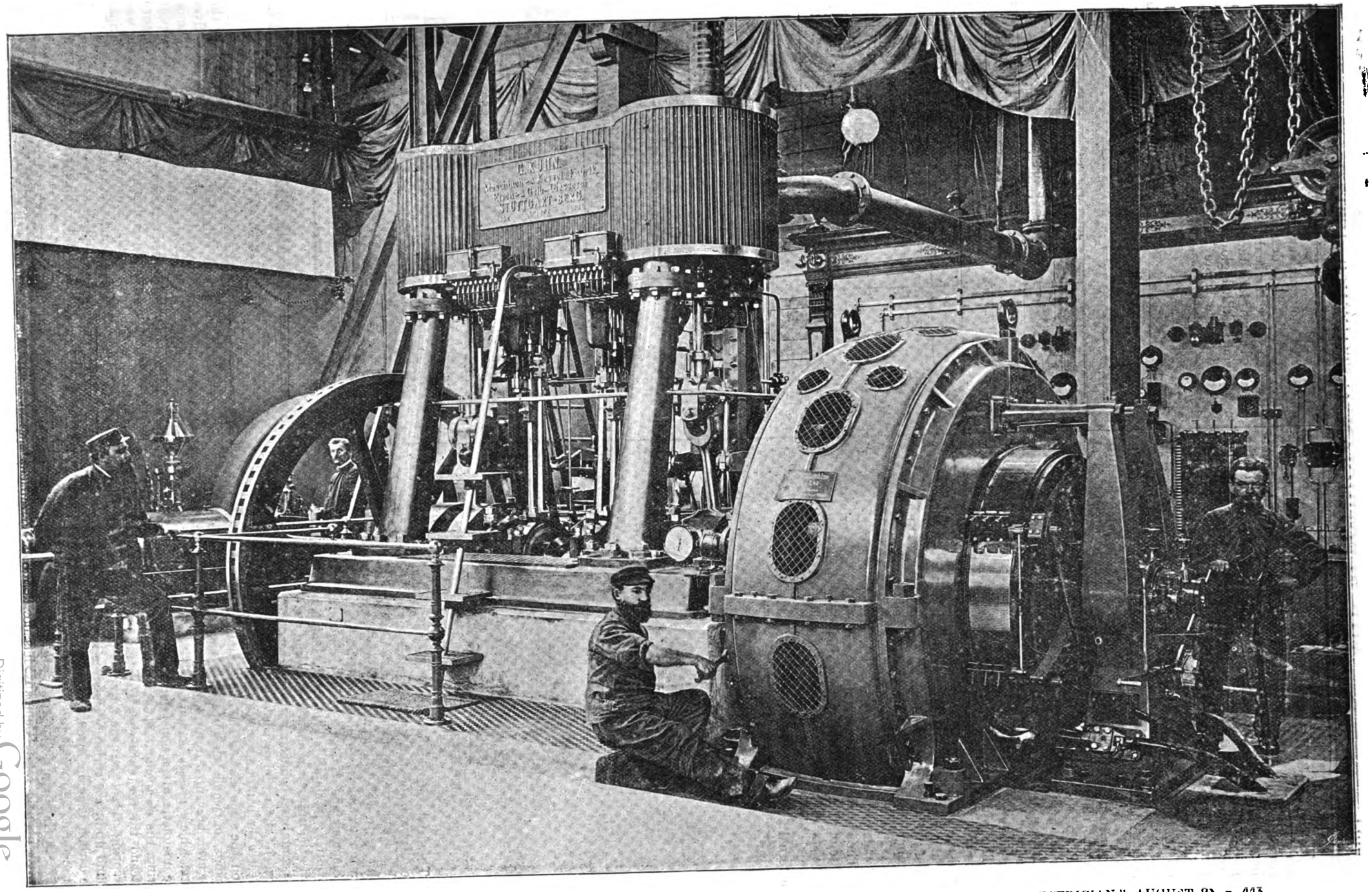

SCHUCKERT 320-H.P. DYNAMO, COUPLED TO KUHN COMPOUND ENGINE, FRANKFORT EXHIBITION, DESCRIBED IN "THE ELECTRICIAN," AUGUST 21, p. 443.

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The measurement consists simply of shifting u or loading the scale till the pointer r stands at zero on the scale t. The result of the measurement expressed in H.P. is found by dividing the product of the number of kilogrammes indicated by the pointer and of the lineal velocity of the belts in metres per second by 75. From this it is seen that when once the instrument is set up, the work of measuring is very simple, being reduced to an adjustment, if necessary, of the pointer to zero, before setting the instrument in motion, this being done by means of the moveable weight on r (Fig. 3), and an ordinary weighing process. The adjustment of the centre of gravity of the revolving parts prevents the centrifugal force having a disturbing influence on the measurements. The instrument is at present made in five sizes, ranging from measurements of 24 H.P. up to those of 300 H.P., all at a belt speed of 30 metres per second.

It should be mentioned that to prevent a sudden throw of the lever g (Fig. 4) against the sides of the pulleys two adjusting screws $h\,h'$ are introduced.

The astatic volt dynamometer for recording pressure of Siemens and Halske is the result of a long series of experiments, and the example shown in their laboratory at the Exhibition is a highly finished and well-made instrument. It is intended chiefly for the use of linesmen, and is provided with a scale reading directly in volts, so that there is no need to take the square root or multiply by a constant, which in this instrument is made as nearly as possible unity.

The instrument depends, of course, on the same principles as those of the well-known electro-dynamometers of this firm. It consists of two sets of coils, the two moveable ones being wound in opposite directions, so as to cut out the effect of external fields.

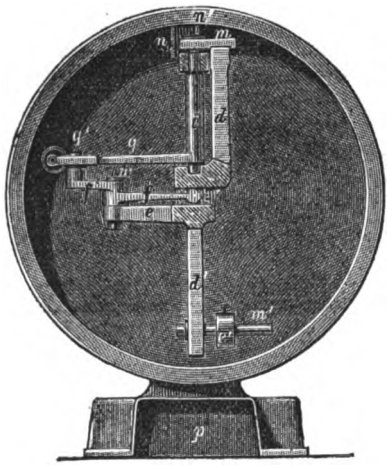

FIG. 5.—Sectional Elevation, transverse.

The fixed coils can be either placed in series or in parallel, the divisions of the scale then denoting either 1 volt or $\frac{1}{2}$ volt. Thus the instrument can be used for pressures up to 90 volts or to 180 volts, and, of course, works equally well with continuous and alternating currents.

Siemens and Halske "band" lamp forms one of their latest novelties; its name is due to the long copper band which supports the upper carbon. It is wound on a drum whose axis is horizontal and connected with an escapement which on being let loose by the action of the electromagnet or magnets, gradually releases the band and with it the upper carbon. The armature is on the same axis as the drum, and is acted on by two spiral springs, of which the upper is the more powerful, but is, however, prevented from pulling home by the end of the armature, which presses against a fixed support. As soon as the magnetic attraction overcomes the force of the upper spring, the escapement is let loose and the band and carbon descend till the spring again overcomes the magnetic force. A spring is set on the interior of the drum and this is wound up by the action of the descending carbon, so that when the carbon is again lifted the drum revolves under the action of the spring and winds the copper band on to it.

Mr. C. H. Stearn, who was formerly director of the Swan United Electric Light Company, has now removed to Zurich, and started the manufacture of glow lamps there, in connection with the Zürich Incandescent Lamp Company. He has taken with him from England the engineers and others who were associated with him there, and is now turning the Zurich natives into skilled glow-lamp makers. The lamps have to pass many tests before being declared ready for sale, among them being a very severe one for vacuum with an induction coil. The lamps are largely used at the Exhibition, about 5,000 being used in some 23 different installations. The following are some data relating to the lamps manufactured by the above firm.

Watts required by Lamps of different Candle-Power.

Candle-Power.	5	10	16	20	25	32	50	100
Watts.	17·5	35·0	56·0	70·0	87·5	112·0	175·0	3·500

Amperes.

Volts.	Candle-Power.							
	5	10	16	20	25	32	50	100
50	0·35	0·70	1·12	1·40	1·75	2·24	3·50	...
55	0·32	0·64	1·02	1·27	1·59	2·04	3·18	...
65	...	0·54	0·86	1·08	1·35	1·72	2·69	...
100	...	0·39	0·56	0·70	0·87	1·12	1·75	3·50
105	...	0·37	0·53	0·67	0·83	1·07	1·67	3·33
110	...	0·36	0·51	0·64	0·80	1·02	1·59	3·18
115	...	0·34	0·49	0·61	0·76	0·97	1·51	3·04
120	...	0·33	0·47	0·58	0·73	0·93	1·46	2·92

Ohms (hot).

Volts.	Candle-Power.							
	5	10	16	20	25	32	50	100
50	142·9	71·4	44·6	35·7	28·6	22·3	14·3	7·14
55	172·9	86·4	54·0	43·2	34·6	27·0	17·3	8·64
65	...	120·7	75·4	60·4	48·3	37·7	24·1	12·1
100	...	285·7	178·6	142·9	114·3	89·2	57·1	28·6
105	...	315·0	196·9	157·5	126·0	98·4	63·0	31·5
110	...	345·7	216·0	172·9	138·3	108·0	69·1	34·6
115	...	378·0	236·0	189·0	151·0	118·0	76·0	38·0
120	...	411·0	257·0	205·0	165·0	129·0	82·0	41·0

[We have plotted the figures of the second of these tables with the following result.—ED. *E.*]

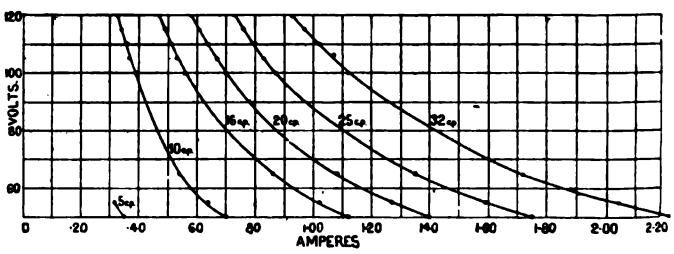

FIG. 7.—Curves showing the Relation of the Candle-Power with the Voltage and Current.

MAGNETIC CIRCUITS AND THEIR MEASUREMENTS.*

BY H. E. J. G. DU BOIS.

Ten years ago, when the first amazement produced by the wonders of electricity had subsided, engineers set themselves to detail work, and attempted to design reasonable dynamos and motors. The history of steam engines began to repeat itself. For this they wanted a theory; but in the literature of electro-magnetism, though voluminous enough, nothing was found that could be utilised. Since then, the two principal worthies of science, British and Continental, have stated that, in their concordant opinion, all that was wanted might at the time have been found ready by diligent searchers. Allusion was made to writings (in the reverse of chronological order) of

* Translated and abridged from a Paper read in Section I. of the Frankfort Electrical Congress, September 11, 1891.

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Maxwell, Sir Wm. Thomson, Faraday, as far back even as Euler.

However this may be, engineers, finding no assistance from science, helped themselves. History will give them due credit for this; science can do no better than annex the ground covered on that side, in a state, however, modified to suit her wants, and cleared from much that is superfluous or even wrong.

During the last decennium, investigations appeared by Bosanquet (1883), Rowland (1884), Werner v. Siemens (1884), Gisbert Kapp (1885), Pisati (1890), in which closed electromagnetic systems are considered analogous to electric circuits, and have Ohm's law applied to them. However, I hold the latter to essentially involve that the ratio of E.M.F. to current is constant, irrespectively of the amount of current. Now, the magnetic flux of induction (alias number of lines of force) is neglecting hysteresis, a single-valued function of the so-called magnetomotive force; but these quantities not being in the least proportional, it seems to me unwarrantable to introduce their ratio as a resistance in the sense of Ohm's law. This would lead one to divide the argument of any function by the latter, and introduce the quotient as a mathematical resistance against the increase of the function. In physics we would then have none but ohmic laws.

The conception of the magnetic circuit is doubtless a fruitful one, and the introduction, for practical purposes, of an (essentially variable) resistance may be recommended. But I think the use of Ohm's name is sufficiently widespread already, and should not be tolerated in connection with our present subject. Still less should magnetic shunts be treated under the auspices of Kirchoff and his rules, such treatment giving nothing but false results.

These criticisms do not apply to the Hopkinsons' classical Paper, which marks the modern epoch of the subject. In fact, they never mention an ohmic law; they simply start from two absolutely safe propositions, viz.: (1) The many-valued lamellarity of H; (2) the solenoidality of B; the latter is, of course, *the* theorem in the "tubes-of-force" theory. Their Paper is often considered a practical one, on account of the dynamo experiments in it. But science claims it as hers for the essentially scientific method followed.

I would now principally show how we may manage without tubes of force, the importance and elegance of which is not in the slightest degree denied. We may go as far by considering, in the old-fashioned way, magnetisation at individual points in the iron. We need not even be physically ultra conservative to prefer this method to looking at the magnetic circuit as a whole, because recent experiments teach us to consider magnetisation as the quantity physically more fundamental than induction. However, within the range occurring in practice, these quantities do not differ by more than the factor 4π.

I was glad to find that Prof. Ewing to a certain extent follows my method in his latest paragraphs on the magnetic circuit, published in *The Electrician*; on the other hand, I regret that after so excellent an exposition my present remarks may appear rather superfluous.*

I.

In terms of the old theory of magnetic induction, as classically expounded in Maxwell's treatise, the behaviour of an ellipsoid of revolution is determined in the now well-known manner by the factor N; we might appropriately call this the "self-demagnetising factor," though a shorter name would sound better. Such an ellipsoid with the closed tubes-of-force surrounding and pervading it, may, of course, be conceived as a magnetic circuit; however, in the present case, this would certainly not lead to so simple a mode of representation.

As regards magnetic circuits in the more usual sense, their simple type is a thin ring, uniformly and peripherically magnetised and provided with a radial air gap. This case is reducible to the preceding one as soon as the factor N is known. It is found that

$$N = \cdot 035\ a \text{ or } = \tfrac{1}{8}\ p,$$

where a is the width of the slit in degrees, p the same in hundredths of the mean periphery. This result is most simply obtained by considering the line-integral of the self-demagnetising force which must vanish when taken around the ring; it is deduced for an infinitely narrow gap. The result may be put somewhat plausibly by considering the gap as a magnetic shell; for this we may substitute the equivalent current almost uniformly counteracting the rest of the uniform winding. The action of such local coils on rings has been experimentally investigated by Oberbeck in 1878.

The amount of deviation of the above equation from the truth with increasing width of the gap must be determined by experiments. These are now being made by Mr. H. Lehmann in the Berlin University laboratory. This ring (shown to the audience) is turned out of Swedish plate; it is uniformly wound with three primary and one secondary layers. The gap now covers $\frac{1}{4}$th per cent. of the circumference; preliminary experiments gave good agreement with theory for intense magnetisation. When the latter is less (as would occur in practice) a sufficiently constant value of N was found; this is smaller than that given by theory in a ratio which must be related to the leakage coefficient of the tubes of force theory. Details will be published after the completion of the experiments.

The two typical cases, ellipsoid and ring, have now become entirely comparable. The curve of magnetisation, I = funct. (H) for endless pieces (infinitely long ellipsoids or closed rings) I shall call the normal curve. From it we find the curves for shorter ellipsoids or for rings gradually opening out by Ewing's "shearing" of the diagram. We soon see the curves merging into a characteristic form adapting itself to two straight lines. The first of these passes through the origin and forms an angle, $\tan^{-1} N$, with the axis of ordinates. The second runs parallel to the axis of abscissæ at a distance corresponding to the maximum values of the magnetisation. The first straight line depends upon the shape of the magnetised body only, the second upon the material, whereas the point of intersection is determined by both. The same holds for the parts of the curve near each of the straight lines. Now we may, at least as an approximation, consider these as the asymptotes to an hyperbola, th equation of which is found to be

$$x = N\,y + \frac{P}{1-y} \text{ or } x = \frac{N\,y + (P - N\,y^2}{1-y},$$

here P is a second constant; the unit of ordinates is the maximum magnetisation.

It is interesting to compare this with the old well-known hyperbolic curve of O. Frölich, the equation of which (in the above convenient unit) may be written:

$$y = \frac{1\,Q\,x}{1 + 1\,Q\,x}, \text{ or } x = \frac{Q\,y}{1-y},$$

Here Q is that value of k for which y becomes $= \frac{1}{2}$; *i.e.*, the iron is "semi-saturated" or, as Prof. Silvanus Thompson has it, reaches its "diacritical point." The equations are seen to differ by the term $P - N\,y^2$ in the numerator. Frölich's curve has a different flatter shape than the one deduced above, and it is always impossible to give Q a value so as to fulfil the conditions prescribed. From the purely electro-magnetic point of view, I therefore prefer my own hyperbola, leaving it to competent judges to decide on the practical applicability of Frölich's curve of "effective magnetism."

In conclusion, I remark that the "shearing of the diagram" is not restricted to ellipsoids and rings, but may be applied (approximately) to bodies of any shape. The mean factor, N, for a given shape may be found by experiment. Lord Rayleigh's original construction is thus generalised to the utmost.

II.

A few applications remain to be mentioned.

In the first place a question exists, the solution of which may now be attempted. It is the construction of electro-magnets for producing fields as strong, as uniform, and as extensive as possible. The problem is well-defined; its conditions essentially differ from those which have to be fulfilled, say, in a dynamo; still a rational solution must be feasible with our

* The original German paper was prepared before these articles appeared; so far as the ground is already covered by Ewing, the present English translation is therefore considerably cut down.—d.B.

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theory. In any case something better may be expected than the purely empirical types now used. It is hardly necessary to dwell upon the importance of such improved apparatus for further experimental advance in magnetism.

In the air-gap of the ring above mentioned we may obtain a field of almost 20,000 C.-G.-S., with a current of 20 amperes. By general theorems of Sir Wm. Thomson's on similar electromagnetic systems, we get the same on magnifying the whole arrangement, say, to five-fold linear dimensions, and using the five-fold current of 100 amperes. By conical pole-pices, bored if necessary (Fig. 1), we may considerably concentrate the field, though its extension and uniformity are thereby reduced. We know more about such cones now from late investigations by Stefan, Ewing, Czermak, and Hansmaninger. We have still to cut through along C (Fig. 1), in order to be able to vary the distance of the poles within certain limits. Such an electromagnet is being built at present from my designs by Messrs. Siemens and Halske.

In conclusion, I have to demonstrate an instrument intended to meet the want of a rapid and simple method for determining magnetic curves of materials used in machine construction. The existence of a demand seems to be proved by the number of attempts made to supply it. We have Hopkinson's bar-and-yoke, Swinburne and Bourne's differential inductive method, Silvanus Thompson's permeameter, Rœpsel's open-circuit torsion apparatus, Eickemeyer's differential magnetometer, Corsepin's siderognost, Bruger's bismuth spiral apparatus. It appears that in America Edison and others proposed various other arrangements, about which we never heard much. It would

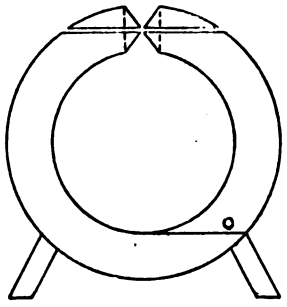

Fig. 1.

lead too far to enter into a description, or even a critical discussion, of all these more or less known instruments. I restrict myself to shortly describing a new solution of the problem and showing the apparatus.

The leading constructive principle was to insert the cylindrical test sample as the principle resistance into a magnetic circuit. As it is quite impossible to reduce the rest of the resistance so as to make it negligible it must be capable of being simply corrected for. It therefore consists for the greater part of air, for the smaller of Swedish iron of large cross section. The induction B in the circuit has to be measured, and it is very tempting to do this by means of the considerable tension of the lines of force in the air-gaps, which amounts (in kilogrammes) to very nearly $(B/5{,}000)^2$.

The tension might be measured in different ways, *e.g.*—1. By sucking in an iron ribbon. 2. By manometrical determination of the hydrostatic pressure in a liquid filling the "interferric" spaces.* 3. By compensating the tension by weights. I chose the latter method as the simplest, though not direct-reading.

The practical application is realised in this magnetic balance (of which Fig. 2 gives a rough idea). The test sample T, which need not necessarily be circular, is cut to a length of 15cm., and automatically clamped between the two massive vertical uprights U_1 and U_2. It may be subjected to fields up to 500 C.-G.-S. by the coil C, of length, 4π cm., so that field $= \frac{1}{10} \times$ ampere-turns. Above the uprights a yoke, Y, is eccentrically supported; magnetic attraction, equal on both sides by symmetry, therefore produces a resulting moment on account of the unequal leverage. This is compensated by a weight, W, sliding along a scale.

* French, *entrefer* (Hospitalier).

The yoke is balanced and adjusted so as to make its purely static equilibrium almost neutral. On magnetising it then becomes unstable; the position of the weight is read on the scale, which just pulls the yoke off the insulated contact screw I. The instant of breaking contact is best determined through having a galvanoscope, bell or telephone in circuit; it is perfectly well defined. The iron surfaces are, of course, prevented from touching by the stops I and S, over which the yoke plays like a Morse key; its motions, of very small range, do not appreciably affect the magnetic resistance of the whole circuit.

The apparatus was calibrated by means of a sample of 1 sq. cm. cross section cut out of the same Swedish plate as the ring above mentioned; its normal curve was, therefore, known. With a small secondary coil and ballistic galvanometer the flux of induction, G, in the central part of the test-piece, was measured for different values of the magnetising field. If the percentage leakage of the circuit be made sufficiently independent of the magnetisation, the scale-reading is proportional to the square of the flux, as above determined. By adjusting the weight and screws the factor of proportionality may be made a round number. The magnetic curve, as found with the sample in the balance, was drawn beside the normal curve, and from the differences of the abscissæ the factor N was at once known. This remains a constant characteristic of the balance, provided the cross-section of the samples afterwards tested does not differ too much from 1 sq. cm.

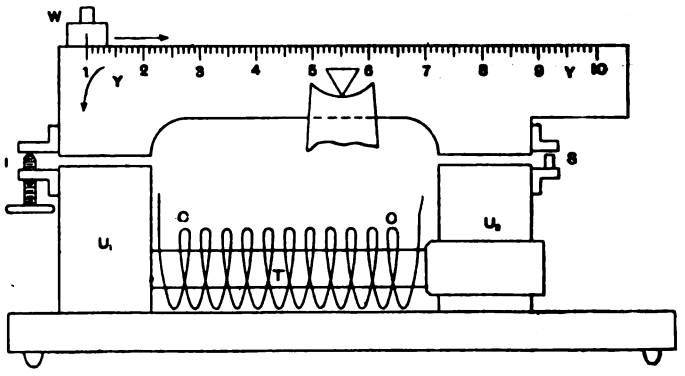

Fig. 2.

Magnetic curves may afterwards be obtained simply by measuring the current in the coil and balancing the beam. They are best drawn directly from an axis of ordinates inclined towards the left through an angle equal to $\tan^{-1} N$. The balance exhibited was made from my working drawings by Mr. W. Oehmke, of the Berlin Physiological Institute; it has the following constants:—

H Field (C.G.S.)	... ...	$= 50 \times$ Current in coil. (amperes)
G Flux of induction (C.G.S.)		$= 1{,}000\,\pi\,\sqrt{\text{scale-reading.}}$
or B Induction (C.G.S.)	...	$= \frac{1{,}000\,\pi\,\sqrt{\text{scale-reading.}}}{\text{cross-section.}}$
or I Magnetisation (C.G.S.)	...	$= \frac{250\,\sqrt{\text{scale-reading.}}}{\text{cross-section.}}$
N		$N = 1/60$
Range		$1{,}700 > I > 0$

"L'Industrie."—In order that Belgium may possess "a journal of science and industry comparable with the great industrial publications of other countries" the journals *Ingénieur-Conseil*, *Industrie Moderne*, and *Industria*, have amalgamated; and the result is a new journal called *L'Industrie*, which seems likely to prove superior to either of the constituent journals both in matter and illustrations.

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A THIMBLE FOR DRAWING CABLES INTO CONDUITS.

When drawing electric cables into pipes, Callender-Webber cases, or other conduits, it is necessary to make a secure connection between the cable and the rope by which it is to be pulled in. It is also necessary that such connection should be small enough to pass through the pipe or case. The method usually adopted at present is to make a splice by cutting out the centre strands of the conductor and "marrying" the outer strands to those of the rope. A gripping device has been

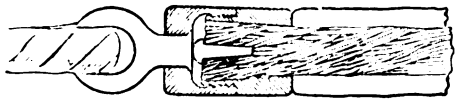


FIG. 1.—Section through thimble, ferrule, and cable.

designed by Mr. A. A. Voysey, of 95, Drury-lane, to avoid the waste of time and material entailed by this method. It consists of a ferrule two or three inches long, tapered inside, and made so that the narrow end fits closely to the conductor of the cable. The ferrule is placed on the end of the conductor, narrow end foremost, the insulation being cut back two or three inches, according to the length of the ferrule. When it is in position, a tapered pin

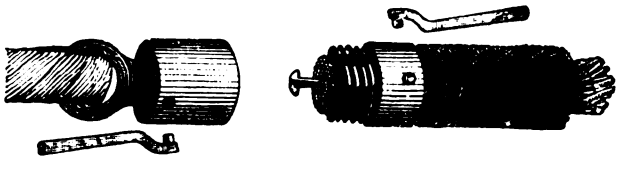


FIG. 2.—Ferrule attached to cable, and spiked. Thimble ready for screwing on.

is driven into the centre of the cable, and this spreads the strands so as to give a tight grip. It is easy to see that any attempt to pull the ferrule off will now cause it to grip the strands more tightly. A cap or thimble is connected to the end of the hauling rope by means of a swivel, and this is screwed on to the ferrule. Thus in two or three minutes a joint (of smaller diameter than the cable) can be made capable of sustaining any strain required.

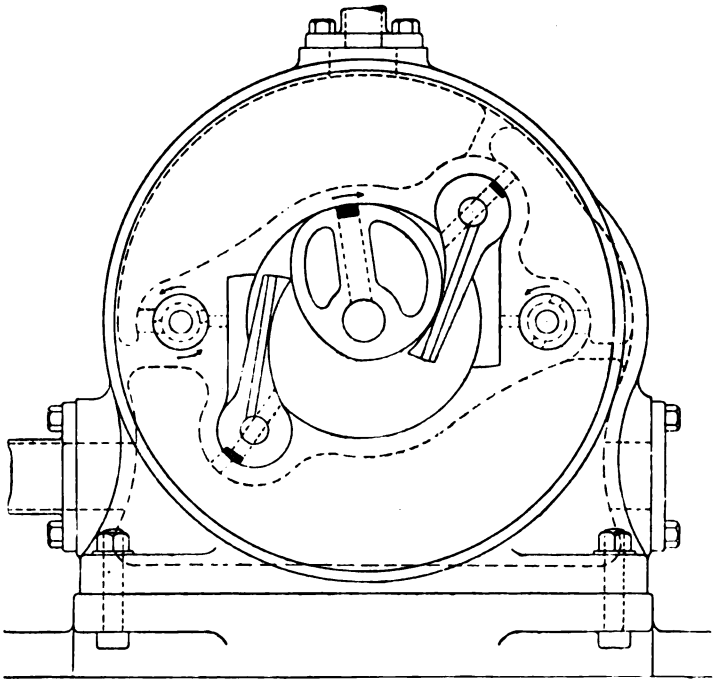
FIG. 3.—Exterior view of connection.

After the cable is drawn in, the ferrule can be easily removed by taking out the tapered pin, which is provided with a small head, so that it can be knocked out without difficulty. This thimble has been used in practice and is found to work well. The saving of time is important, since the cost of keeping the whole gang waiting must be taken into account, and there need be no waste whatever of the cable.

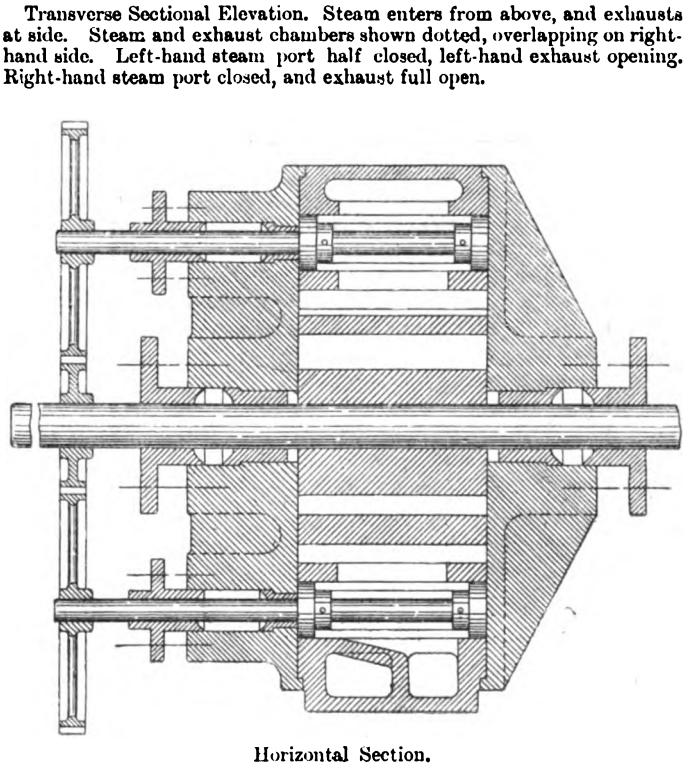
THE BROWN PATENT ROTARY ENGINE.

There is a singular fascination for many mechanical minds in the invention of rotary engines; and it has been observed by the inventor of one of the most successful ones that if his invention would not do for an engine it would work as a pump, or if no good as a pump it would make a good stone-crusher. Reauleaux has classified a large number of "Chamber crank trains," and it is rare to find a rotary engine that is not illustrated in that interesting work. The type of the one which we illustrate herewith is well known, and several attempts have been made to introduce it practically. One of the most recent examples was that of the Hodson Engine, exhibited at the Crystal Palace in 1881, but which has not been heard of again. The piston of this engine is an eccentric drum keyed upon the main shaft, revolving in a cylinder, the contents of which are divided into steam space and exhaust space by means of flaps. The accompanying illustration explains itself.

The novel feature of the Brown engine is the arrangement of admission and exhaust valves. The former are cylindrical, and are driven by gear wheels from the main shaft, and, therefore, revolve continuously. The exhaust passages pass through the flap valves, and this arrangement allows a good steam dis-



Transverse Sectional Elevation. Steam enters from above, and exhausts at side. Steam and exhaust chambers shown dotted, overlapping on right-hand side. Left-hand steam port half closed, left-hand exhaust opening. Right-hand steam port closed, and exhaust full open.



Horizontal Section.

tribution to be obtained. The cylinder is 10½in. in diameter by 8⅝in. in length. The drum occupies nearly one half the volume of the cylinder. The independent adjustment of the steam valves allows the cut-off to be given at any desired point, and effective cushioning to be produced. Prof. Jamieson has made a test of the engine, and found that at a mean speed of 574½ revolutions per minute, and a B.H.P. of 20·8, the feed water per B.H.P. was 37·91b. per hour. The report of Prof. Jamieson contains indicator diagrams, which have been

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re-drawn with certain modifications from those which were taken during the test. The mean effective piston area and effective stroke of this engine is not readily ascertained, and without a full explanation as to this, much information cannot be obtained from the diagrams. The feed water per indicated horse-power hour is given at 22·72lb. The report alludes to various corrections, which may be introduced into these figures, and says that there is no difficulty as far as the engine is concerned in increasing the speed to 800 or 1,000 revolutions per minute. The engine is remarkably compact, and is, we understand, being further improved.

It was found necessary in the Hodson engine to duplicate the arrangement in order to balance the parts of the revolving masses to some extent, and there was great difficulty in reducing the noise and vibration.

The weak point in this type of engine is the difficulty of maintaining a steam tight fit. The revolving drum has a longitudinal packing piece bearing against the circular wall of the cylinder, and two radial pieces bearing against the ends. The flap valves are also provided with radial bearing strips, but have to make a rubbing contact on the surface of the drum, bearing sometimes on their faces, and at other times on their edges, and being held there by the pressure of the steam. This "high pairing" and "force closure," as it is called in Prof. Kennedy's Translation of Reauleaux, makes it rather doubtful if the arrangement can be kept steam tight.

ON THE RELATION OF THE AIR GAP AND THE SHAPE OF THE POLES TO THE PERFORMANCE OF DYNAMO-ELECTRIC MACHINERY.*

BY HARRIS J. RYAN.

The object of this Paper is not to deal with the subject in a new light, but to add to its literature a limited amount of data, the deductions from which go to establish the correctness of the ideas and the utility of the suggestions put forth in the Papers read by Messrs. Swinburne and Esson at the meetings of the Institution of Electrical Engineers on Feb. 13 and 20, 1890. Up to the

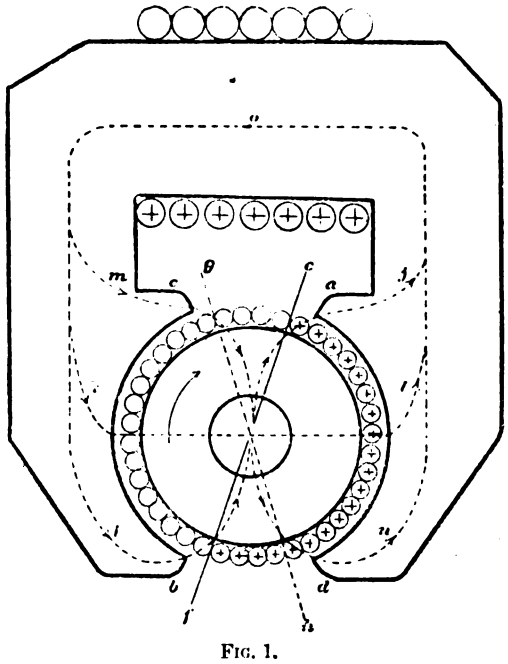

FIG. 1.

time of the publication of these Papers, the air gap was usually treated by contributors to electrical literature as an evil in a dynamo, having a necessary existence, and the smaller that it could conveniently be made the better. The shape of the poles had often been spoken of as having a somewhat decided effect on the performance of the dynamo, while but little had been said regarding the cause of such an effect.

* A Paper read at the 59th Meeting of the American Institute of Electrical Engineers, New York, September 2, 1891.

There exists some difference of opinion as to what should be known as the number of ampere-turns on an armature. For our present purpose we will assume that

$$\text{Armature ampere-turns} = \frac{\left\{\begin{array}{l}\text{The number of con-}\\ \text{ductors on the sur-}\\ \text{face of the armature}\end{array}\right\} \times \left\{\begin{array}{l}\text{Strength of cur-}\\ \text{rent in the arma-}\\ \text{ture conductors}\end{array}\right\}}{\text{Number of poles.}}$$

Referring to Fig. 1, it is evident that when we consider the magnetic forces acting in a working dynamo by the route O, I, J, O, that the entire number of ampere-turns on the armature are directly opposed in action to the ampere-turns on the field. By the route O, M, N, O, all the ampere-turns on the armature except those that lie between the double angle of lead, G, E, are acting with the field ampere-turns, while those between G, E, are opposed to the same. Therefore, by this route the total number of ampere-turns actually aiding the field ampere-turns is the total number of armature ampere-turns, minus twice the number of ampere-turns that lie between the double angle of lead. By the route O, K, L, O, the number of ampere-turns acting is the number of ampere-turns on the field, minus the number of ampere-turns that lie between the double angle of lead. We can then estimate with ample practical accuracy the magnetic density in the air gap at all points, for any given total amount of magnetisation through the armature. The ampere-turns that lie between the double angle of lead are

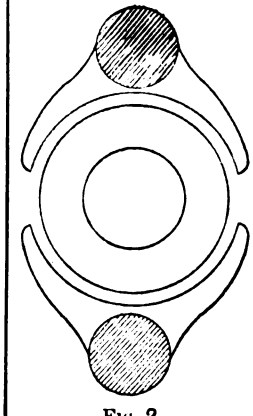

FIG. 2.

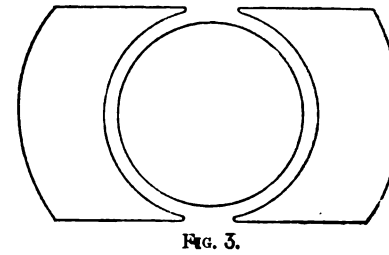

FIG. 3.

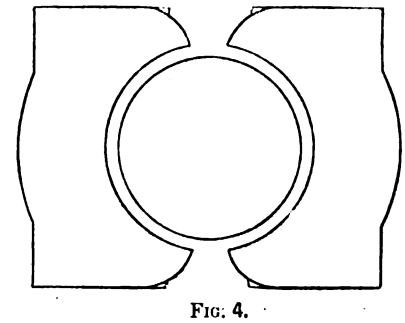

FIG. 4.

opposed to the action of the field ampere-turns at all points. It is evident that the portion of the armature ampere-turns not included between the double angle of lead will increase the magnetisation through the air gap by the route O, M, N, O, just as much as they diminish it along the route O, I, J, O, as long as magnetic saturation does not take place in the strengthened pole corners C, D. If the pole corners are thin, as in the types shown in Figs. 2, 3 and 5, saturation is apt to occur. It is then that the magnetic resistance increases by the route O, M, N, O, and the magnetic density by this route is no longer increased by the same amount that it is diminished along the route O, I, J, O. On the other hand, when the pole corners are fashioned as seen in Figs. 4 and 6, so that saturation in the strengthened pole corners cannot occur in practice, the current in the armature can produce no modification of the total amount of magnetisation through it, other than that which is produced by the action of the ampere-turns that lie between the double angle of lead. This action can always be compensated for by putting an equivalent number of series ampere-turns on the field acting with the field ampere-turns. The double angle of lead can be determined with sufficient accuracy, for with pole corners slightly extended at the centre, see Fig. 11, the diameter of commutation at all loads is very near the weakened pole corners. The pole corners are slightly extended at the centre, so that the coils always enter the field of the weakened pole corners gradually. The E.M.F. developed in the coils as they pass under the poles can never be far different from that actually needed to

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reverse the current in the coil when passing under the brush. In this way the point of commutation in a dynamo can be kept the same when carbon brushes are used without undue sparking, as long as the armature does not reverse the magnetisation under the weakened pole corners.

From the discussion of the magnetic relations of an armature to its field in a dynamo in connection with Fig. 1, it is seen that the magnetisation in the air gap under the weakened pole corners becomes zero, when the armature ampere-turns are equal to the ampere-turns on the field, whose magnetising force is impressed between its pole faces through the armature. This impressed magnetising force is that due to the difference between the total number of ampere-turns on the field and the number of ampere-turns required to set up the magnetisation through the field cores, from pole face to pole face. In order to commutate the current without spark at the commutator, the magnetisation in the air gap under the weakened pole corners should never be allowed to become zero. It follows, then, that the field ampere-turns impressing a magnetising force between the pole faces must always be somewhat in excess of the maximum number of ampere-turns on the armature. The amount of this excess need only be sufficient to insure a positive field at A and B, Fig. 1, strong enough to reverse the current in the coils as they are commutated. When a certain amount of magnetisation is to be set up through an armature with

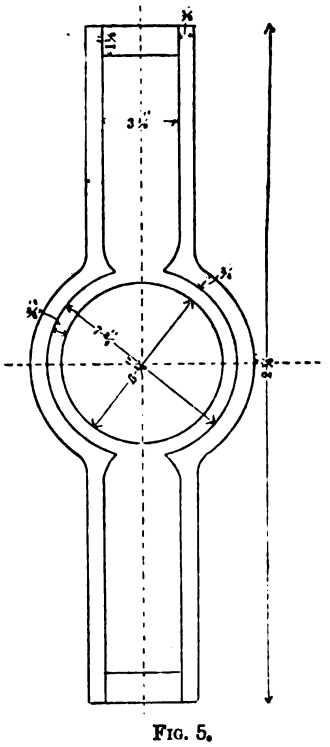

Fig. 5.

the application of the magnetising force of a given number of ampere-turns impressed between the pole faces, we must provide the requisite amount of magnetic resistance between these pole faces. The value of this resistance will have to be such that the impressed field magnetising force will establish the desired amount of magnetisation. This resistance in most cases is best provided for in a proper length of air gap. In general it is found best to avoid heating in the armature core as far as consistent, by the use of comparatively low magnetic densities for wrought iron. The magnetic resistance of the armature core under these circumstances is very small and may be neglected.

The magnetic resistance between the pole faces is occasionally provided for largely, either through a saturated core of a ring armature, saturated lugs on armatures where the wires are placed in grooves, or both. This, in addition to what air gap may be necessary from a mechanical point of view, goes to make up the total amount of magnetic resistance that is provided between the pole faces. Machines of this order have been developed largely through the old and rather expensive method of experimentation. This method has given us some types in which ordinary results are arrived at through rather extraordinary means. Take the case of a machine with a ring armature, wires wound in grooves, a very small air gap, and poles shaped somewhat as shown in Fig. 2. Such a machine operated as a dynamo may require only a quarter of the number of ampere-turns that it will have on the armature at full load for field excitation in order to produce a certain E.M.F. at a given speed. Yet this machine produces a fairly constant potential at the brushes under all variation of load, and without undue sparking at the commutator, in the following manner.

For the production of a constant E.M.F. at constant speed the total magnetisation through the armature must remain constant. At no load one-fourth of the ampere-turns needed on the field at full load are provided by a shunt winding. This shunt winding is sufficient to set up the total amount of magnetisation for the production of the normal E.M.F. of the machine when there is no current in the armature. Now, in order to take the normal current from the armature without reversing the magnetisation under the weakened pole corners, three times as many series ampere-turns as there are shunt ampere-turns must be added to the field. The addition of these series ampere-turns must not increase the total amount of magnetisation through the armature, which is accomplished by the thin pole corners. The strong pole corners become saturated when the armature is furnishing even a small amount of the normal current for which it is designed. For most values of the current, then, the armature ampere-turns tend to diminish the magnetisation under the weakened pole corners, but cannot increase it correspondingly under the saturated pole corners. The action of the series ampere-turns on the field prevents the reduction of the magnetisation under the weakened pole corners to zero, while the saturated portion of the pole-pieces prevents the increase of the total magnetisation through the armature, and thus a constant potential is maintained.

The "armature characteristic" IV. plotted in Fig. 7, was taken from the machine of the above sort, built with cast-iron fields. The cross-section of the field cores proved on trial to be too small, and became strongly saturated at full load,—while they were quite a little under the point of saturation at no load. This curious result for a constant potential generator was due to the increased magnetic leakage, produced as the series ampere-turns on the field came up with the load. Saturation took place as the curve indicates, when the armature furnished a current of about 140 amperes, and no possible compounding could ever make this generator produce even approximately a constant potential, with variation of load. Steel cores of the same dimensions were substituted for the cast-iron cores. Saturation did not occur in them due to magnetic leakage. The pole corners were very thin, as in Fig. 2, and the "armature characteristic" III. was obtained. The machine was then furnished with a shunt winding that produced a slightly

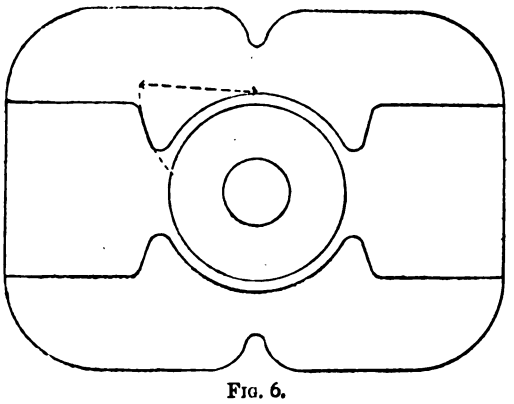

Fig. 6.

smaller number of initial ampere-turns than Curve III. indicates as required to produce 125 volts, and with series turns at such a number that the total number of ampere-turns on the field for any current developed by the armature is shown by the broken line drawn through Curve III. It was under these conditions that the machine performed in the manner described above, did not vary more than 5 per cent. from the normal E.M.F. on either side, or a total variation of 10 per cent. It was then almost entirely rebuilt. The armature was provided with a core that was considerably larger in cross-section, and the maximum magnetic density used in it was 11,000 lines per sq. cm., as against 20,000 used before. The lugs on the core were dispensed with, and the wires wound on the surface of the core. The poles were made of cast iron, and fashioned to accord more nearly with those in Fig. 3. The air gap required ten thousand ampere-turns to set up the magnetisation through it at no load, while the armature ampere-turns were 8,000 at normal output, so that series ampere-turns had only to be added to counteract the action of the ampere-turns on the armature that lie between the double angle of lead, to increase slightly the E.M.F. by the amount equal to the fall of potential through the armature caused by its resistance, and to compensate for the slight effect of the pole corners that still became saturated to a limited extent for the higher outputs. It should be remembered that the magnetic leakage that takes place between the adjacent north and south pole corners, one of which is strongly and the other weakly magnetised, plays an important part in saturating thin pole corners. It is evident that unless the "armature characteristic" is a straight line as in Curve I., Fig. 7, the machine cannot be made to regulate for constant potential with a high degree of refinement. The poles

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were again changed and shaped as in Fig. 4, when an "armature characteristic" given in Curve I. was obtained, and the proper number of shunt and series ampere-turns for a refined degree of regulation were readily decided upon. These experiments confirm what has been said above, and show how useless have been the attempts to diminish the air gap beyond certain limits.

It was shown on the outstart how we can calculate the actual magnetic densities in the air gap for any total magnetisation through the armature, for any armature current. The results of the following experiments confirm the correctness of these methods. The diagrams in Fig. 8 give the values of the magnetic density at all points of the air gap of a generator producing 125 volts at the brushes and 80 amperes. The following are its dimensions and data :—

Diameter of armature core	6·25 in.
Length of armature core	12 in.
Diameter of bore of poles	7·19 in.
Double depth of air gap	0·94 in.
Armature sections	50
Turns per section	2
Resistance of armature	0·06 ohm.
Poles shaped as in Fig. 3,	
Shunt turns on field	6400
Field current, no load, 125 volts	1·48
Field current, full load, 125 volts	2·10
Speed	1600

Carbon brushes used without lead.

The "armature characteristic" curved considerably, indicating that the pole corners become saturated. It is evident, too, that the normal magnetisation in the pole corners in addition to the magnetic leakage which is greater there than anywhere else, produced saturation in all pole corners, even with no current in the armature. For at full load there were 4,000 ampere turns on the armature, while 4,000 series ampere-turns had to be added to the field that produced 125 volts at no load to keep the E.M.F. the same. Therefore at full load we have the same number of ampere-turns acting through the weakened pole corners as at no load, and the total amount of magnetisation has only been increased 5 per cent., to compensate for the resistance of the armature conductors. The conditions, however, are not the same, for there are just 4,000 more ampere-turns to cause magnetic leakage at the pole corners, so that on the whole the magnetisation in them is increased. This increase of magnetic density in them greatly increases their magnetic resistance, for they are saturated to begin with. It is on this account that we find the magnetisation under the weakened pole corners diminished, when apparently the forces acting have not been changed. The magnetisation under the strengthened pole corners through the air gap is increased more than it is diminished by the effect of the added magnetic leakage, through the 8,000 additional ampere-turns that act to produce magnetisation by this route through the armature.

In Fig. 9 the diagrams show the magnetic action of the armature of a 10 H.P., 110 volt motor, with poles fashioned as in Fig. 6. Measurements of the magnetic leakage were made on this motor, and the results indicate that the shape given to the pole corners avoided saturation in them even at full load. The double angle of lead was almost 60 deg. The ampere-turns embraced by it on the armature were partially compensated for by 9 series turns on each of the consequent fields. The remainder of the armature ampere-turns that lie between the double angle of lead serve to weaken the field by just the amount required to produce a constant speed. The following figures give additional data on this motor :—

Diameter of armature core	8·33 in.
Diameter over all	9·0 in.
Bore of poles	9·38 in.
Double air gap	1·05 in.
Shunt turns on field	2200
Shunt current at 110 volts	3·55
Ampere turns on field at 110 volts	7800
Ampere turns on armature at full load	5750
Armature sections	48
Turns per section	3
Speed	1200

The ampere-turns required to set up 2,600 lines per sq. cm. through a distance of 1·05 in. or 2·64 cms. in open air—

$$\frac{2600 \times 2{\cdot}64}{1{\cdot}26} = 5600.$$

This is the number of field ampere-turns that exerted their magnetising force between the pole faces through the armature. The ampere-turns acting through the weakened pole corners are, therefore, very near zero, which is entirely corroborated by the fact that the magnetisation was observed to be zero at this point. (See full load curve in Fig. 9.) Through the strong pole corners the ampere-turns acting were the 5600 of the shunt ampere-turns, + the 720 of the 9 series turns + the armature ampere-turns, 5750—twice the ampere-turns between the double angle of lead, 2 × [·3 × 5750], or 3400 = 8670 which will produce a magnetic density through an air gap of 2·64 cms. depth of

$$\frac{8670 \times 1{\cdot}26}{2{\cdot}64} = 4100,$$

while the actual magnetic density measured at this point was 3950, an agreement within the possible limit of error.

In Fig. 10 are given curves showing the magnetic performance of an armature, with its conductors laid in deep narrow grooves, as shown in Fig. 12. The clearance on each side was one-sixteenth of an inch, making the double air gap one-eighth of an inch. Additional dimensions are as follows :

Diameter of the armature core	6·0 in.
Length of armature core	6·0 in.
Resistance of armature	·34
Number of sections	64
Turns per section	3
Output, amperes	20
„ volts	100
Speed	1800

Curve I., in Fig. 10, shows the distribution of magnetisation at 112 volts, no current, a speed of 1800, and a field excitation of 2,600 ampere-turns. Curve II. shows the magnetic distribution for an output of 97 volts and 24 amperes, at a speed 1800, and a field excitation of 2600 ampere-turns. Curve III. shows the magnetic distribution at an output of 40 volts and 20 amperes, at a speed of 1800, with a field excitation of 750 ampere-turns. This same excitation, when the armature furnished no current, produced an E.M.F. of 48 volts, at a speed of 1800 revolutions. The poles were shaped as in Figs. 11 and 12, but modified as explained below. In making these experiments carbon brushes were used, and their position maintained at the normal diameter of commutation. An average magnetic density in the air gap of 3400 lines per sq. cm. was required to produce an E.M.F. of 112 volts. The grooves on the armature in which the conductors were placed occupied one-half of the armature surface, so that the actual magnetic density in the air gap was 1·8 times this average magnetic density. The ampere-turns required to set up this magnetic density in the air gap were

$$\frac{{\cdot}125 \times 2{\cdot}54 \times [3400 \times 1{\cdot}8]}{1{\cdot}26} = 1520,$$

which is the number of field ampere-turns whose magnetising force is impressed between the pole surfaces through the armature, when it furnishes 112 volts and no current. The ampere-turns on the armature at a current of 24 amperes are

$$\frac{2 \times 64 \times 3 \times 12}{2} = 2300,$$

as against 1520 impressed by the field. Under these circumstances the magnetism under the weakened pole corners is reversed, as is also clearly indicated by Curve II., in Fig. 10, or the Curve C E D F C, in Fig. 11. This curve also shows that the magnetic density under the strong pole corners was 5,100 lines per sq. cm. Now in building this machine, six longitudinal slots, 1¼ inch deep, were cut in each pole immediately back of the surface, which enables us to be sure of the exact densities in the pole corners for a given distance. For a depth of 1¼ inches immediately back of the pole-faces, these slots took up one half of the cross-section of the poles. Then a density, therefore, of 5,100 really means a density of 10,200, or a strong saturation for a distance of 2½ inches in the cast-iron of the poles. The magnetising force required to produce 10,200 lines per sq. cm. through cast-iron is 200 per centimetre length. Therefore the ampere-turns required to establish this density through 2½ inches are

$$\frac{2{\cdot}5 \times 2{\cdot}54 \times 200}{1{\cdot}26} = 1{,}000.$$

The total number of ampere-turns acting to produce magnetisation through these strong pole corners was the sum of the field ampere-turns that impressed the magnetising force from pole face to pole face through the armature, and the ampere-turns on the armature covered by the poles. The poles covered approximately 85 per cent. of the armature surface, making this value 1,500 × [2,300 × ·85] = 3,400. Of this number, as was just shown, 1,000 were utilized in producing the magnetic density of 5,100 through the saturated portion of the poles. The remaining 2,400 ampere-turns exerted their magnetising force in producing the average magnetic density of 5,100 through the air-gap, and affords another opportunity of checking these ideas of the action of the armature on the field. For the ampere-turns required to set up an average magnetic density of 5,100 through the air gap under consideration were :

$$\frac{[1{\cdot}8 \times 5{,}100] \times {\cdot}125 \times 2{\cdot}54}{1{\cdot}26} = 2{,}300$$

which checks with the above value as well as could be expected. When the armature furnished 24 amperes, the E.M.F. at the

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brushes was 97 volts, while with no current it was 112 volts. Of this drop of 15 volts, 8 are accounted for by the resistance of the armature, and the extra 7 were caused by the saturated pole corners. By operating this same machine at an E.M.F. at which the pole corners could not saturate with normal output of current, we have demonstrated for us in a very striking manner that the armature ampere-turns cannot change the total magnetisation established through the armature by the field when the pole corners do not saturate. The E.M.F. with the armature current at zero was brought to 48 volts with a separate field excitation of 750 ampere-turns. Then when the armature was allowed to furnish 20 amperes the E.M.F. at the brushes dropped to 40 volts. Of this drop of 8 volts, 7 were produced by the resistance of the armature. Yet the field is powerfully distorted by the armature current, as may be seen by reference to Curve III., Fig. 10, or the

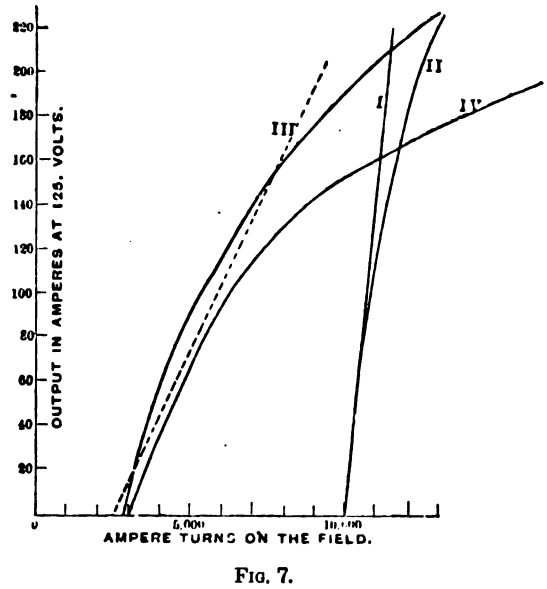

Fig. 7.

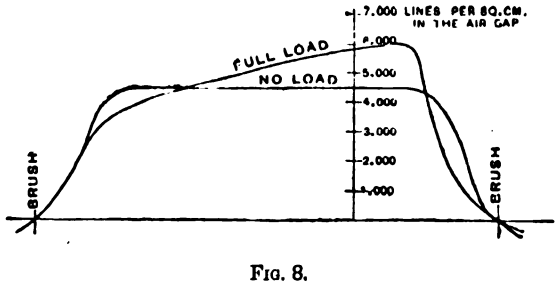

Fig. 8.

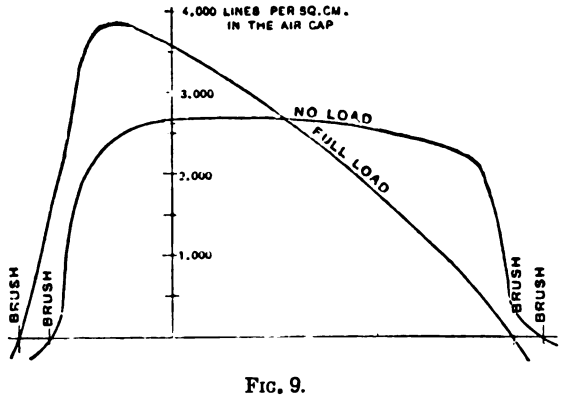

Fig. 9.

curve A, D, C, B in Fig. 12. Even with this very great rearrangement of the magnetisation produced by the armature current, the total magnetisation set up by the field is practically unchanged. The difference of potential on the commutator between the points A, B, Fig. 12, was observed to be 72 volts. This excess of E.M.F. over that which was produced at the brushes, the figure shows clearly to be due to the magnetisation produced by the armature through itself and the strengthened pole corners. The points where the field is zero are at A, B. They mark the diameter through which the ampere-turns encountered on the armature are just equal and opposite in action to the ampere-turns of the field that impress a magnetising force between the pole faces through the armature. A simple computation will show that this is true. The field ampere-turns that impress magnetising force between the poles when the armature produced an external E.M.F. of 48 volts are

$$\frac{1,520 \times 48}{112} = 650.$$

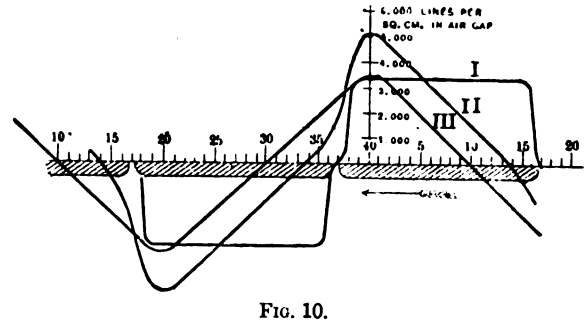

Fig. 10.

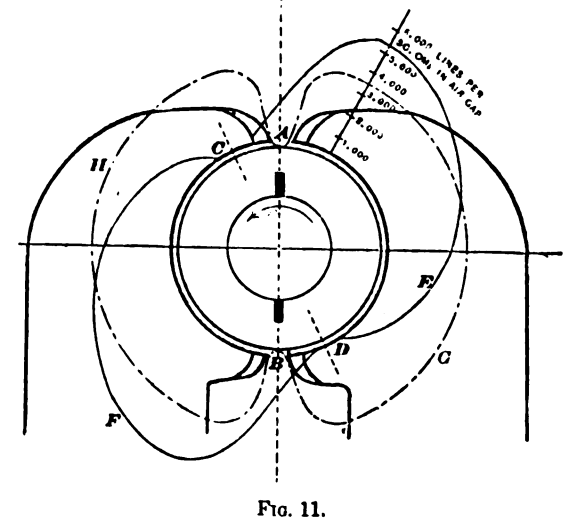

Fig. 11.

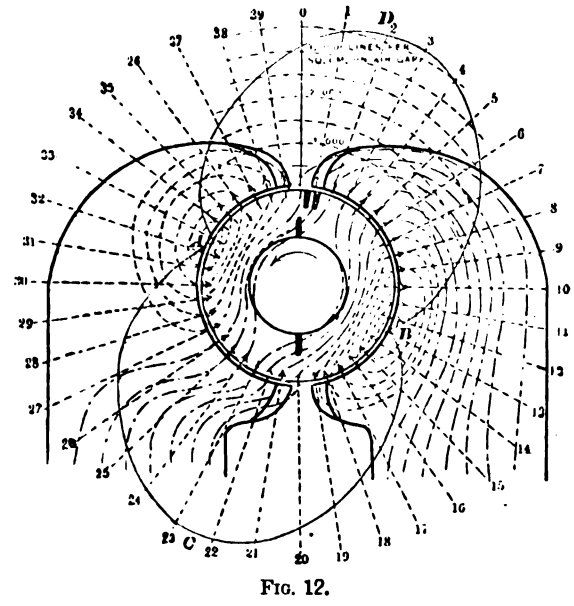

Fig. 12.

The ampere-turns on the armature opposed to the magnetisation set up by the route A B are 12/40 of the total number of ampere-turns on the armature (*see* Fig. 12), or

$$\frac{12 \times 64 \times 3 \times 20}{40 \times 2} = 576.$$

This is a fair agreement when we consider the accuracy with which the original data may be determined.

Mr. Esson, in his valuable Paper above referred to, discussed the requisite features for a generator for constant current, with

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closed coil armatures, in which regulation is effected by shifting the brushes. He stated that the field should be uniform at all points, under the poles, and that the armature core should be saturated. These statements are a little misleading. The magnetising force impressed by the field ampere-turns must be uniform at all points between the pole faces. This is accomplished by proportioning the poles so that the strongly magnetised pole corners will not become saturated when the brushes have their extreme position for the development of the highest E.M.F. that the machine is to produce. The air gap is made of such a depth that the ampere-turns required to set up the magnetisation through the armature, without current, and for the production of the highest E.M.F. that the machine will be called on to give, shall be a little more than the armature ampere-turns when it furnishes its normal current. Then as long as the brushes are kept under the pole-faces, the non-sparking point will be wherever the brushes are placed. This will be the case whether the armature is or is not saturated. A practical demonstration is found in the following experiment: A Siemens and Halske dynamo, with magnet and armature cores, whose shape and dimensions are shown in Fig. 5, was used.

Length of armature core	7·25in.
Number of armature sections	56
Turns per section	6
Revolutions	1,000
Output in volts	50
„ „ amperes	30

The field was separately excited with 4,000 ampere-turns on each of the sets of consequent poles. Regulation could then be effected for a constant current in the armature of 22 amperes, by shifting the brushes from no E.M.F. to 35 volts without the slightest sparking even when metallic brushes were used. Within this limit the pole corners did not saturate. The field cores were wrought and the yokes cast iron. When the armature circuit was broken it was found that the field excitation of 4,000 ampere-turns produced an E.M.F. of 50 volts. The magnetic density in the field cores, including leakage, was only 11,000 lines per sq. cm. Therefore, of the 4,000 ampere-turns on the field, not more than 200 were applied in setting up the magnetisation from pole face to pole face through the field cores. It is safe to assume, then, that of these 4,000 ampere-turns 3,800 were active in producing a magnetising force impressed uniformly over the pole faces through the armature. The same value is obtained by the method adopted in the previous cases. That is by calculating the magnetic density in the air gap when 50 volts were developed, and then deducting the number of ampere-turns required to establish such a magnetic density through a 1½in. air gap. As to the armature, when it produced 22 amperes its ampere-turns numbered

$$\frac{2 \times 56 \times 6 \times 11}{2} = 3{,}700,$$

or an excess of 100 ampere-turns impressed by the field over and above those on the armature. As long as this same number of ampere-turns was maintained on the field it was not possible to regulate for a constant current of a lower or a higher strength without sparking. The impressed field ampere-turns are in excess of the armature ampere-turns by that amount which is just sufficient to produce a weak positive field that will reverse the current in the coil when its terminal bars at the commutator pass under the brush. When regulation is effected by this means it is seen that all pole corners are alike magnetised, and at the centre of the pole faces the magnetisation is zero when the machine is short-circuited. At full output, at the highest E.M.F., the magnetisation under the one set of pole corners is almost zero, and under the other set it is at the maximum value that is ever obtained. In a generator of this type, when the poles are made stout enough at all points, the total amount of magnetisation through the armature, at all loads, will remain at a constant value. When used for operating long arc lamps a "drooping characteristic" can better be obtained by saturated field cores than by saturated pole corners and armature core.

What has been said of dynamos applies equally well to motors. The only difference being that the non-sparking points are on opposite sides of the diameter at which magnetisation is zero in the air gap. This is due to a well-known cause. In a motor the armature rotates in an opposite direction when field and armature currents remain the same as in a dynamo. The E.M.F. of self-induction caused by the reversal of the current in a current has not changed, while the E.M.F. developed in the coil by the field has changed sign with the change of the direction of rotation. The result is that the reversal of the current in an armature section must take place in a weak field of an opposite sign in a motor from what it does in a dynamo, when sparking is to be avoided entirely.

The action of the current in the armatures of multipolar dynamos and motors will be the same as that found for two pole machines.

PETROLEUM OIL ENGINES.*

BY PROF. WILLIAM ROBINSON.

Since the successful introduction of the oil engine by Messrs. Priestman Brothers, of Hull, in 1888, many engineers have been at work, and not a few attempts have been made to use ordinary petroleum oil at once as fuel and working agent in the internal combustion engine.

Approaching the problem with the knowledge gained in gas engine work, one is led to convert the oil partially into a fixed oil-gas by heat, overlooking the tarry and other products formed, which sooner or later make their presence felt by clogging the valves, passages and working parts to such an extent that the engine soon stops short in the hands of the critical user and forfeits the title of a thoroughly reliable working engine.

Experience then leads to the conclusion that a really commercial and successful oil engine must use the oil as *oil* and not as *oil-gas*, unless the latter be cooled and cleansed. Hitherto, for large gas engines, above 40 H.P., and for small ones too, without gas supply, the heavy intermediate oils have been converted into real gas, by means of a *gas-producer*, and this oil-gas when cooled takes the place of coal gas.

Now, instead of the *gas-producer*, we find in *one class of oil engine* a retort, spiral coil of tubing, or other *vaporiser* in which the oil is heated and converted into *vapour* by a lamp or oil-burner. A mixture of this vapour and air is drawn into the cylinder, and the charge is compressed before ignition—the cycle of operations in the engine cylinder being usually that of Beau de Rochas, as in the well-known "Otto" gas engine.

For example, Messrs. Crossley Brothers, of Manchester, are at work upon an oil engine in which a lamp performs a two-fold function—first, to heat and evaporate the oil as it is pumped into a cast-iron retort or vaporiser, and, second, to heat the tube igniter which is timed by a valve similar to that in their gas engines. This lamp has a separate supply of oil given to it by a pump and an air jet fed from another pump worked by the same lever as the exhaust valve. The current of air carries up the petroleum vapour and makes it burn.

The details of this and several other attempts at workable engines of this class are still in the transition stage.

Again, for the petroleum *spirit engine*, there are many *air-carburetting and heating devices* to evaporate the highly volatile hydro-carbons which make up the lighter products of petroleum, such as benzoline and gasoline. The vapour so formed readily condenses again at moderately high temperatures when subjected to pressure in the engine cylinder. However, the terrible danger and risk in the transport and storage of these light oils prohibit their common use for this purpose.

When considering oil engines the fact should not be forgotten that we have an entirely different condition of things to that connected with steam or gas motors, because the engine has to prepare or gasify the oil for its own use. For instance, a steam engine that will run for a day with good results may be expected to run in a similar manner for a long period. The boiler is relied on to supply dry steam at the desired pressure. The same may be said of the gas engine, where we have simply to turn on the gas-cock, and rely upon the ingenuity and skill of those who manufacture the gas to make it of such quality as to give equally satisfactory results in the motor cylinder, whether used for a short or longer period. But when we come to the oil engine we meet with a different state of things as regards supply of the working agent. The oil must be taken direct from its cistern, thoroughly mixed with the right proportion of air, and passed into the cylinder ready for ignition, at the rate, in some engines, of *four separate charges per second*; so that, unless the arrangement for dealing with these heavy oils is correct and works with precision, the tendency to clog in the cylinder and working parts is very great. In fact, to use a homely example, the engine is like a strong looking man with a poor constitution and suffering from pulmonary troubles, it will run well for a short time and then, getting choked up, refuses to work.

In the Priestman *spray maker* and *vaporiser*, specially designed to avoid clogging of the working parts, we have a neat and practical combination of the two methods of treating the oil. A sprayed jet of oil is first broken up by compressed air playing on it in the inverted spray nozzle, then it is further mixed with air, heated, and completely vaporised by the hot products of combustion from exhaust led round the vaporiser or mixing chamber before being allowed to escape. This is really a *regenerative* and heat-saving arrangement. The oil vapour, thus thoroughly mixed with air in the proper proportions, is drawn through an automatic suction valve into the engine cylinder by the piston in its forward stroke. In order to cleanse the air of dust and dirt it is found necessary to

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draw it into the oil reservoir and spray-maker through layers of cotton wool, which are renewed from time to time.

The action of this spray-maker (shown) will be seen by the following experiment:—1st. Turn off the air supply, and a flame does not light the unbroken oil jet; next, allow the air under pressure to break up and thoroughly spray the oil; the vapour formed is so intimately mixed with air that it rises in a cloud, and can easily be ignited, burning with a bright flame. On the other hand, incomplete vaporisation takes place, when heavy particles of hydro-carbon are seen falling below the vapour cloud, due to want of air-pressure and consequent incomplete breaking up of the oil jet. Hence the proper proportions of oil and air must be maintained whatever be the strength of charge required, and every spray-maker must be carefully tested, adjusted, and the supply passage graduated for different conditions of running to control the action of the engine in the hands of the user.

The amount of hydro-carbon is diminished or increased, together with the amount of air, so as to form a high explosive charge, or a low one, according to the work to be done by the engine. The action is thus:—A small portion of the air which is slightly compressed (4 to 12 lb. above atmospheric pressure) in the oil cistern of the engine enters the passage to the inverted nozzle and meets the oil which has been forced by the same pressure of air through another passage. The oil jet is thus vaporised by the air forced upon it, and comes out in the shape of a hollow cone or cloud to be still further mixed with a larger body of air admitted by the wing-valve in another passage. The air for spraying and the oil through the centre tube are kept at one regular pressure whether the engine is running light or with full load, but the amount of air through the wing valve-passage is rightly proportioned to mix with the oil which is allowed through the V-shaped slot, cut in the conical plug regulated by the governor. The auxiliary body of air after being drawn into the *mixing chamber*, during the out stroke by the piston in the working cylinder, is prevented from escaping by a small retaining valve. By this means there is a regular explosion and impulse every cycle, giving admirable regularity in running.

The compressed charge in the cylinder is fired by an intermittent electric spark, made to play between the ends of two platinum wires, insulated by porcelain rods in the *igniting plug* and connected to the secondary circuit of an induction coil excited by a storage cell of about 2 volts, which has been known to work more than 1,100 hours.

The *double-cylinder vertical launch engine* is specially designed for running at high speeds. In the 5 H.P. marine type of Priestman engine, each cylinder, water jacketed in the usual manner, is 7″ diameter by 7″ stroke, and arranged to give an explosion or working stroke every revolution of the fly-wheel or heavy disc. The valve gear is admirably simple and ingenious. The movement of the eccentric rod which is timed to open the exhaust valves against stiff spiral springs, on the return of the inner stroke of the piston, is double acting, making it both a thrust and a pull-rod instead of thrust only as in the single cylinder engines. The inlet valves are self-acting, the charge being drawn in by the suction of the piston during its out-stroke. The air pump which forces oil out of the tank is worked by an eccentric from the counter shaft, while the water circulating pump is connected to the same eccentric. The mixer or vapour chamber is supported from the cylinders above the oil cistern. The inlet valve of the spray-maker is fitted to the vapour chamber similar to the horizontal type. The governor is worked by mitre pinions with a belt from the crank-shaft, which regulates the inflow of oil and air. Ignition is by the electric spark, and the contacts can be adjusted to make explosion early or late. The actual horse power at 250 revolutions per minute is 5·7 and 9·1 indicated horse power.

The horizontal type is also remarkably self-contained, and specially adapted for electric lighting installations. The Priestman engine has already been used to great advantage for pumping and hauling in collieries, for rock-drilling in mines, as well as for agricultural and a very large variety of other purposes. In fact, the sphere of usefulness of this oil engine is rapidly extending, because it is found reliable and steady at work, with decided economy of fuel. The only reasonable objection is that of smell, which may be reduced by ventilation.

What has undoubtedly to be arrived at in the construction of oil engines is to get economy of oil and the best mechanical results without clogging of the working parts, so that in the critical hands of the user the engine may run cautiously without attention or frequent cleaning and repairs. Clogging is prevented in the Priestman by thoroughly mixing the oil vapour with a large proportion of clean, atmospheric air, so as always to form an explosive mixture which gives complete combustion and a clean exhaust.

It must be pointed out, however, that during the compression of the charge before ignition a portion of the vapour comes into contact with the walls of the cylinder, &c., and condensing on them *never* gets burned. Still this oil forms, in its heated state, a most excellent lubricant for the piston, thereby dispensing with the need of a more costly oil, and regulating the same without any attention. The perfect state of the piston surface after being months at work affords ample evidence of the advantage gained by this method of self-lubrication with a minimum of trouble.

I have also proved that this slight condensation takes place by comparing the pressure along the compression curves of indicator diagrams with the pressure obtained by experiment from each charge consisting of the explosive mixture of ·015 cubic inch of oil with 191 cubic inches of air at the same temperature as in the engine. Taking the temperature of the charge 170°F. (which experiment has proved the most successful in the Priestman engine) on entering the cylinder, the cards show the highest pressure, before ignition, only 38lb. per square inch. This is kept low for fear of much condensation as well as to give smooth running.

I may here briefly notice my investigation of the relation between the pressure and temperature of the vapours from the different burning oils, intermediate oils, and some heavier lubricating oils, in order to throw some light on their action and behaviour in the cylinder of the common oil engine; at the same time I have tried to find out which oils are best adapted for this use.

My experiments prove that, notwithstanding the complex and varied character of the different oils examined, the law according to which the pressure of petroleum vapour varies with its temperature is represented by a perfectly regular curve for each oil. Moreover, the relative steepness of these curves is somewhat similar to that of the fractional distillation curves of the same oils. "Royal Daylight," the ordinary lamp oil supplied by the Anglo-American Oil Company, distils off gradually through a wide range of temperature. This oil is suitable for oil engines, and can be obtained in almost every village in the kingdom. The wholesale price is, at present, 5½d. per gallon, and there is reason to prophesy that this may be considerably reduced. "Water White" and "Lighthouse" oils give still better results. Crude petroleum, containing, as it does, light volatile hydro-carbons, as well as the very heavy constituents, is extremely dangerous in handling, and unsuitable for use in oil engines.

Another, and by far the simplest type of oil engine is that in which the oil is injected directly as oil into compressed and heated air in a cartridge, which at once acts as a vaporiser and combustion chamber. In this way heavy intermediate oils of specific gravity ·850 can be dealt with equally as well as the ordinary burning lamp oils. This type has not yet got completely beyond the transition stage, since it has been only about a year in a workable and useful shape. Such an oil engine is the invention of Mr. H. Akroyd Stuart, of Bletchley, and is now being made by Messrs. Hornsby and Sons, Grantham A novel feature of this engine is, that the ordinary gear for firing the charge by heated tube, flame or electric spark are dispensed with altogether, and heavy oil is ignited and completely burned when injected into the compressed and heated air in the red-hot vaporiser or cartridge. The cartridge is heated up quickly at start by the fierce flame of a special oil lamp urged by air blast from a small fan driven by hand. This *starting lamp* is merely a small cast-iron pot with contracted nozzle. The lamp is filled with oil up to the level of the fan pipe inlet. A small piece of asbestos or other packing, about ⅜in. thick, by 2in. long, is dipped in the oil, lit, and pushed through the hole with plug (shown) into the oil. Air from the fan is blown on the top of the oil, giving a powerful clear flame, and in from three to five minutes the vaporiser is sufficiently heated, so that a few turns of the fly wheel starts the engine, and then the lamp is extinguished. The cartridge is kept red hot inside by the combustion; and the oil, injected into compressed and heated air containing ample supply of oxygen, burns readily and completely, the exhaust being perfectly clean. There are ribs inside the vaporiser to offer a large heating surface to the oil. A comparatively small opening leads from the vaporiser to the compression chamber at the back of the cylinder, so that there is very little conduction of heat from the vaporiser to the cylinder walls, which are kept cool by the water jacket in the usual way.

The engine is of the simplest design. The working parts are few, and the details are being improved by Messrs. Hornsby, as experience indicates or dictates. The oil is contained in a cistern in the base of the casting, and the supply can easily be replenished at any time during a run by sliding open the top cover and pouring in the oil. Every charge of oil is forced by means of a positive action oil pump, through a thin copper tube and simple nozzle, into the red-hot vaporiser at the proper moment for ignition—just after the air has been compressed into the red-hot cartridge and the piston is on the return stroke. A screw stop adjusts the stroke of the pump to give the right quantity of oil. When the load is thrown off and the speed gets too high the governor lifts a valve and stops the oil supply until the speed is reduced to the normal.

With a large fly and at high speed—about 210 revolutions per minute—the regularity of running of this engine having the "Otto" cycle under full load and then light—was much better than I expected. In order to secure uniform speed for electric lighting, the tendency is in this direction, and as I take it rightly too, to

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use larger fly-wheels on the internal combustion engines and run at much higher speeds than heretofore. Several of the Hornsby-Akroyd engines may be seen running in London, at Bletchley, and Grantham. I tried a 6 H.P. engine during a run of about three hours, using oil of specific gravity ·854 and flashing point 220°F., and the rate of consumption was less than a pint per brake horse-power per hour—(sets of indicator cards taken). Even heavier oils might be tried, the hot water from the water jacket going to heat up the heavy oil and keep it in a sufficiently fluid state fit for use in winter.

The action in the engine cylinder, although the same cycle, is here very different from that in the Priestman oil engine, inasmuch as there is an excess of air in the cylinder, and this is compressed before the oil is injected. Consequently the combustion is rapid, and will be complete even when heavy oils of great heating power are used. Since the air is dry and there is no condensation of oil the cylinder requires independent lubrication, as in the case of the gas engines.

Safe Storage of Oil for Oil Engines.

A feeling of safety to the public naturally tends to the use of heavy oil, from which the lighter constituents have been driven off or distilled. I have found the loss in weight for some heavy oils by prolonged heating at low temperatures, keeping the oils exposed to the air and allowing free *evaporation*. Known weights of oil were taken in shallow dishes, about 3in. across top, and gently heated in a sand bath by a very small steady flame for three hours, the temperature of the oil being kept constant.

The proportion of volatile constituents present in three samples are indicated :—

EVAPORATION.

Name of sample.	Specific gravity 60°F (15·5°C)	Constant temperature (Centigrade)	Time of evaporation (hours).	Per-centage loss.	Total per-centage loss in 3 hours.
Broxburn "Light-house" oil, used in Priestman engine	·811	40° to 45 60 to 65	1·5 1·5	1·63 5·27	6·90
Intermediate shale oil	·846	40 to 45 65 to 75	1·5 1·5	1·12 2·45	3·57
Lubricating oil, used in Hornsby-Akroyd engine..	·854	40 to 45 60 to 65 Steam bath95	1·5 1 5 3	1 00 1·95 12·62	2·96 12 42

The terribly explosive character of the hydro-carbons driven off at the ordinary temperature renders the *safe storage of petroleum* imperative. Instead of the present tank system, Mr. B. H. Thwaite has devised the safety oil tank. It is very much like a gas holder, the cover-plate being kept in contact with the oil and counterbalanced by weights to give only a slight pressure of one or two inches of water on the surface of the oil. The frame moves into an annular water seal stand pipe to draw off any gas that collects.

There is no necessity for the introduction of air to allow the tank or holder to be emptied, and as the oil is kept cool and always under pressure it is impossible for a dangerous explosive mixture to accumulate inside the tank. Any gas given off during the heat of the day is not lost, but may be collected or partly recondensed at the lower weight temperature, since there is no air present.

One realises the danger of *crude* oil, having light volatile constituents on a hot summer's day with sparks or lightning flashes about.

In the case of heavy distilled oil, the danger is very greatly reduced, and there is practically no danger in the use of this heavy oil for motive power in engines.

ELECTRIC MINING-MACHINERY, WITH SPECIAL REFERENCE TO THE APPLICATION OF ELECTRICITY TO COAL-CUTTING, PUMPING, AND ROCK-DRILLING.*

BY LLEWELYN B. ATKINSON AND CLAUDE W. ATKINSON, ASSOC. MM. INST. C.E.

(Continued from page 592.)

The cutter (Fig. 6) consists of a long bar, either taper or parallel, fitted with a coupling to unite it to the shaft of the machine, and having arranged on it a series of steel tools. The bar, revolving on its axis, acts like a long milling tool, each set of cutters sawing its way through the material. The form used in the coal-cutting machine known as the "Economic" was a parallel bar, having holes in it, into which were fitted steel nibs secured in place by set screws. Some years ago Mr. Grafton Jones suggested the threading of star-shaped discs on to a square or polygonal bar, with a nut at the end to hold them in place. The cutter used by Messrs. Bowers in the first machine tried at their colliery (Fig. 7), was upon this principle. A series of star-shaped cutters made of cast steel having an hexagonal hole in the centre, were threaded on to a steel shaft, and secured by a nut at the end, the nut having cutters screwed into it, so as to clear itself. The result was satisfactory except so far as the wear of the points was concerned. In fairly soft or friable coal, it is doubtful whether they can be much improved ; but in coal which contains much dross or is hard, the cutters are soon blunted, and the power required to drive the machine becomes excessive. After some experiments, in conjunction with Mr. Hans Renold, of Manchester, the form shown in Fig. 6 was devised.

The object in view was to provide a bar which would admit of cutters being used of a much higher grade of steel than was possible with the star-shaped castings previously mentioned, which should have more metal for removing heat from the point of the tool, thus preventing its softening and wear, and which should take, if possible, less power, and at the same time give a

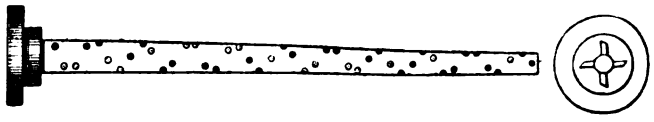

FIG. 6.—Goolden Cutter-Bar.

more steady cutting action, and remove the *débris* which it formed. To effect this, the bar is drilled with a series of holes, each of which is placed in a direction nearly at 90deg. to the next adjacent one, but differing so far from a right angle that one complete turn is made in the length of the bar ; by arranging the cutter in this manner, a left-handed spiral is produced, having a pitch equal to the length of the bar, which serves to equalise the cutting action, and also a right-handed spiral, which has a pitch equal to about one-sixth of the length of the bar, and forms, as it were, a cork-screw to draw the dirt out of the cut. These holes are tapered to about 1 in 30, and pieces of round steel are turned to fit them, the heads being shaped to form the cutter, the exact nature of which depends on the material to be cut.

The proper form to give these tools is a question to which considerable attention has been devoted. Square-shaped, flat-faced tools were tried, of such a width as to overlap one another and remove the whole of the material ; it was found, however, that the power required was excessive. Both square and pointed tools of various widths were then tried, with the result that the form indicated in Fig. 6 has been found to be, on an average, the best. This cutter is of a V-shape, and is placed in the bar with a gauge, so that the surface farthest in the coal is set in such a direction as to clear itself. The edge nearest the machine slopes across the cut, so that when the tool has entered to a depth of about ⅛ to ¼ inch, a wedging action commences, and the ridge of coal left between two

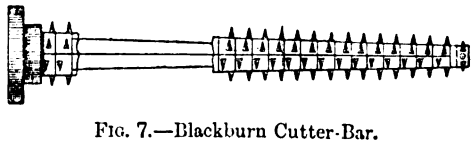

FIG. 7.—Blackburn Cutter-Bar.

succeeding cutters is split off. By this means only about a quarter of the total quantity removed is actually cut away, the remainder being broken off by a splitting action, and the power required for working the machine has been reduced to one-quarter of what it was. Various speeds for operating the bar have been tried, but for fairly hard coal from 400 to 500 revolutions per minute is enough, although in soft and friable coals a higher speed may be adopted. The diameter over the points of the cutters varies from about 5in. at the front of the cut to about 3in. at the back. The tools when blunt are driven out with a hammer, and ground on an ordinary stone in a tool-holder, in which they are set in a taper hole, the holder being mounted eccentrically, so that in grinding the proper backing is given. These cutters are made of an exceedingly high quality of steel, which is tempered dead hard, so that it will easily scratch glass.

The average length that can be cut without changing the bar may be taken in hard coal to be about 40 yards, though as much as 80 yards, in hard gritty coal, has been effected without any stoppage. The blunting of the tools, however, when the edge is once really gone, proceeds rapidly, and out of proportion to the work done, and it is bad economy to force the amount cut to too great an extent. One man or boy attends to the winch, one man follows the machine, spragging and putting up props, whilst a third devotes his attention to the cutter itself, and to clearing the road in front of it.

*Abstract of Paper read before the Institution of Civil Engineers.

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The amount cut by the machine varies according to the nature of the seam, and the experience of the men working it ; but it may be taken that on the average, all stoppages being included, 20 to 30 square yards per hour may be cut in fairly hard coal. As a matter of actual maximum performances, the following results may be cited. At Lord St. Oswald's colliery at Nostell, 55 yards were bared to an average depth of 3ft. 8in. in 75 minutes, and lengths up to 20 yards, where the road is clear for running without stopping, have been often cut to this depth at the rate of a yard a minute. And at Messrs. T. and R. W. Bowers' collieries, where a less powerful motor is used, 110 yards have frequently been bared to a depth of 3ft. 6in. in four hours. The length of cutter-bar usually adopted is from 3ft. 6in. to 3ft. 9in, ; but it is a matter of interest that in a trial at Messrs. Briggs and Co.'s collieries at Normanton, a bar of 5ft. in length was used, cutting underneath to that depth, an amount exceeding considerably the best performance of any previous machine.

The actual horse-power developed by the motor has varied in different cases from 6 H.P. to nearly 15 H.P., but, in the author's opinion, it is a mistake to reduce too far the power available, and 10 or 12 H.P. would seem to be a fair average amount for working rapidly and effectively, with a reserve enabling obstacles to be overcome, without straining the machinery.

Table IV.

Relative Cost of Cutting Coal by Machine and by Hand-Labour.

Thickness of seam	3 feet.	
Cost of cutting, filling, &c., by hand		2s. 6d.
Saving of coal by machine	20 per cent.	
Tons bared per shift	160 tons.	
Labour, steam, cutters, interest and depreciation at 15 per cent.	0s. 3d.	
Cost of filling after machine, taking up floor, laying rails, &c.	1s. 3d.	
Total cost by machine		1s. 6d
Saving over hand-labour		1s. 0d.
Saving in coal		0s. 6d.
Total saving by machine		1s. 6d.

Table IV., Appendix, gives the relative cost of cutting by machine and hand labour in certain cases ; but, although trials have extended over some time, it is, perhaps, too early to speak of what will be the ultimate saving effected by the use of these machines. Great difficulties have had to be overcome, apart from the electrical and mechanical problems, in the prejudice of the men, and in the resistance which they offer to the introduction of labour-saving machinery ; and this has reached such a pitch in some cases that the miners have actually declined to work the machines, or to remove the coal which has been cut by them. These obstacles will disappear in time, but at present they form an element which has to be considered in estimating the cost of coal-cutting by electric power.

Electric-boring and Rock-drilling Machinery.

An early example of the use of electricity in mining was the employment of the electric motor for working rock-drilling plant. This part of the subject has, although apparently simple, proved to be one of the most difficult to deal with ; the reasons of this being—first, that the amount of power required is small, and, therefore, the advantage gained by electricity not so noticeable ; secondly, that very powerful and complete drills, particularly percussive drills, are in the market, and, thirdly, that the use of machine-drills is generally resorted to in cases where the necessity for at once carrying out the work is very pressing, so that the contractors are less willing to try any experimental plant.

Drilling machines may be divided into two classes : (1), rotary, and (2), percussive. A form of rotary drill was shown complete with its own electric motor, and mounted upon trolley-wheels, applicable for use for coal or ironstone boring. The motor, the framework of which is made in one with the bed, is a small ¾ H.P. enclosed mining motor, of the authors' design. The revolving drill-bar has a thread cut along its length, working through a nut which is free to revolve except in so far as it is held by an adjustable brake-band. The result of this is that if the brake be slack no feed is imparted to the drill ; if the brake be tightened so as to prevent the nut revolving, a feed of $\frac{3}{16}$in. per revolution, or any intermediate amount, may be given.

The power is taken from the motor-shaft by bevelled gear, giving a reduction in speed of 1½ to 1 ; it is then transmitted by the vertical shaft and through a worm-gear to another pair of bevels. The total reduction in speed is from 1,600 revolutions per minute to 50 revolutions on the drill spindle. This drill will bore a hole 2in. in diameter in hard coal at a speed of 12in. per minute.

It will drill in slate at the rate of about 3in. per minute, but the principal difficulty in dealing with material as hard as slate is to procure a sufficiently satisfactory fixing to the roof and sides to prevent the whole drill from shifting and getting a cross strain upon it. It is, therefore, principally recommended to be used for coal or ironstone, where rapid sinking through moderately hard material is required. The drill takes about 10 amperes of current, at a pressure of 110 volts. Some experiments made to determine the power actually developed, through all the gearing and on the drill-shaft, show that the ratio $\frac{\text{mechanical power on drill-shaft}}{\text{electrical power}}$ is about 40 per cent.

For dealing with harder rock, diamond drills, working in a similar form of machine, may be used ; but the cost of maintaining diamond drills is so heavy that in general little economy is effected by their use. Percussive rock drills, therefore, are generally used for this purpose. The use of percussive rock drills driven by electricity has, so far, been limited, one of the principal difficulties being the construction of a really suitable percussive action, driven by a rotary motion. An arrangement devised by the authors for driving an Ingersoll rock drill by means of an electric motor was shown. In order to diminish the weight of the drill it is separate from the motor, which is mounted on a trolley, the connection between the two being made by a length of about 8ft. of flexible shafting.

The drill itself is well known. It consists of a bar lifted by a crank motion, connected to the driving handle by a rachet and pawl, in such a manner that after the drill has been lifted by the connecting rods against the pressure of a spring, as soon as the dead point on the top centre is passed, the spring forces the drill forwards, over-shooting the driving handle, which gears again as soon as the blow is expended. Two blows, or nearly so, are therefore given for each turn of the handle, which is designed to make sixty revolutions per minute.

The driving-wheel is geared into a bevel pinion which is carried by an adjustable frame or quadrant and driven direct by the flexible shaft. The speed reduction is in the ratio of ten to one.

The motor, which is of the pattern previously described, and is entirely enclosed, is mounted on a trolley, and has a fibre pinion driving a gear wheel, which gives motion to the flexible shaft. The speeds are as follows :—Motor, 1,500, flexible shaft, 600, drill wheel, 60. This plant may be taken to represent the present position of electric percussive-drilling ; but the authors have been for some time engaged upon effecting the design of a new machine, doing away entirely with a separate motor, giving a direct percussive action and reducing the total weight to a considerable extent. The experiments upon this drill are not yet complete, and therefore, for the present, it will only be mentioned.

Dynamo for Transmitting Power.

Illustrations were given showing in section a class of dynamo well adapted for use in transmitting power for electric mining work, with pressure up to 1,000 or 1,500 volts. The bed is of cast-iron, and a block in the centre of it forms the connecting yoke of the magnets, which are of the "inverted" type, and stand upon it. The magnet cores are of rectangular section, and are made of wrought-iron. The pole-pieces are of cast-iron, or in some cases are forged in one with the magnet-bars. The armature, which by preference is of the "Gramme" type of winding, is composed of a number of thin sheets of charcoal-iron, insulated from one another by paper, mounted upon a phosphor-bronze spider, which is notched into the plates, and firmly keyed upon a stout steel shaft. The magnet may be shunt or compound wound, but in the case of transmitting power from a dynamo to a single motor is preferably series-wound. The commutator is composed either of phosphor-bronze or of hard-drawn copper, insulated with mica. The brush-holders are of a special type, enabling the brushes to be fed through the holder and adjusted by a feeding-screw at the back, thus doing away with the necessity of loosening any bolts or nuts. This is valuable in case of long runs extending over nights and days together, such as often occur in mining work.

Special point is made in these machines of the ample clearance given to the armature in the pole-piece gap ; three-sixteenths of an inch a side is usually adopted, thus allowing room for wear in the bearings and for the expansions which inevitably take place, and obviating the annoyance and delays caused by the armature rotating against the pole-pieces. The shaft and bearings are of large dimensions, compared with ordinary dynamos, for similar reasons, and the precautions thus taken of providing ample margins, not only in the mechanical factors, but also in the electrical design, have contributed largely to the success and freedom from accident which has marked the working of these machines in mining experience. Several of them have been running for periods extending over two or three years, in the hands of persons quite unacquainted with electrical matters, without any breakdown or repairs being necessary, and with very small wear upon the commutators.

Summary.

The instances described will be sufficient to show that :—

A. Electrical power is destined to become an important factor in mining mechanics, on account of the three following reasons :—

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1. The greater facility with which it can be used with machines which require to be moved from time to time as the work advances.
2. The great economy in first cost, and reduced cost of working owing to its efficiency being higher than that of compressed air, or any other medium of power transmission.
3. The smaller cost of maintaining the cables, as compared with piping, on shifting floors in roadways, &c.

B. That the methods described are sufficient to obviate all objections to the use of electric motors in coal-mining, either by excluding inflammable gases, or by constructions which allow of their safe combustion.

C. That the experiments, trials, and practical work, extending over four years, show that—

1. Electrical pumps may be used with advantage and economy for mine draining.
2. Electrical coal-cutters can replace hand-labour, with saving in cost and increased production of coal.
3. Electrical drilling-machines are available in place of machines worked by hand or compressed air.

While doubtless on all these points opinions may to some extent differ, and the particular methods adopted may be subjected to criticism, the authors hope that the subject they have brought forward will be found of interest to the members of the Institution.

The electrical details of many of the machines described are due to Mr. H. W. Ravenshaw, Assoc. M. Inst. C.E., who has used considerable skill in adapting them to meet the conditions required. The authors also have to express their thanks to Messrs. W. T. Goolden & Co., for placing drawings and results of test at their disposal, as also to Mr. R. Hancock for his kind assistance in connection with the preparation of the drawings illustrating this Paper.

DISCUSSION.

Sir JOHN COODE, President, hoped that the question of safety with regard to the use of electricity in coal mines as compared with other methods of conveying power would occupy a prominent place in the discussion. It was a most important point, and should be fully debated.

Mr. LL. ATKINSON desired before the discussion commenced to call attention to one of the cutter-bars on the table which was not described in the Paper. In order to avoid the grinding of the steel points and the expense of renewing these steel cutters, the latter were permanent and had chilled-iron points inserted in them which were nearly as hard as steel, and when worn out could be thrown away, being inexpensive. They had not had much experience with that form, but thought that it would lead to a considerable economy in the item of grinding cutters. He had been told several times lately that although the question of sparking on the motors had been treated in the Paper, they had not dealt with what would be likely to happen should the roof fall, or should the cable be broken from some other cause. The reason was that although they had devised a mode of getting over the difficulty, it was so novel that their experience of it did not justify them in placing it before the Institution. The form of the cable,* however, was such that even should it be absolutely torn asunder by the breaking of the roof, there would be practically no sparking, and an arc was impossible That, he thought, removed the remaining objections to the use of the electric cables in fiery coal pits.

Mr. ALBION T. SNELL said that during the past four years great progress had been made in the use of electricity in mining; and the General Electric Power and Traction Company (Limited), with which he was connected, had from the first been identified with the work. He advocated the use of over-compound dynamos and series or shunt-wound motors, so as to make the system applicable for both lighting and power. He wished to draw the attention of the Institution to a new system of electric haulage for use on stiff brows in mines, by means of a cable or rope, fixed at either end, and lying parallel to the road. The energy was supplied through wires above or beside the track. The system was introduced by Messrs. Immisch and Walker, and was the property of the General Electric Power and Traction Company. The cable was passed over a sprocket-wheel or a friction-clutch geared in a suitable manner to an electric-motor on a small trolley, the whole forming a light and compact electric-locomotive, not depending for its grip on the friction between the wheels and the rails, but getting a direct pull on the fixed rope. The principle was similar to that employed for working floating bridges and barges. At the Wharncliffe Silkstone Collieries a brow about 500 yards long had been equipped in this manner, and the locomotive had been working successfully for about three months. The inclination of the road averaged 4in. to the yard, and the rolling load was approximately four tons. The trolley carried a 10-H.P. electric-motor, and weighed about 20cwt., which was unnecessarily heavy for that particular work. It ran in a headway of about 4ft. 3in., and the current was supplied by an overhead wire. The objection that had been raised with regard to sparking did not apply in this case. Amongst the many interesting points referred to in connection with the application of electricity to mining, was the risk of igniting gas. As far back as 1868, when speaking on the subject before the Midland Mining Institute,† he gave it as his opinion, that under normal circumstances the sparks at the brushes of a motor would not readily fire gas, owing to their having a low temperature by reason of the large masses of metal in contact with them. His opinion was combated by several leading mining experts, and he therefore decided to make experiments to determine the point at issue. With that view he procured a wooden box about six feet long, with an internal cross-section of about a square foot. One end was blocked up and the other had a hinged door, so as to make an easy outlet for the probable explosion. In the centre a small motor and a gas indicator were placed. Ordinary coal gas was admitted from the closed end until the gauge registered an explosive mixture. The motor was then started, and the experiment watched through a glass window in the side. From time to time the sparking was increased by changing the position of the brushes, and the mixture of gas and air was varied through all ranges. It was found that even with excessive sparking the gas did not explode until the commutator and brushes had become heated to a far greater extent than ever obtained in ordinary machines. It followed that although under normal conditions a motor would be unlikely to ignite gas, yet if by any means the brushes and commutator became heated beyond a certain point, the exact temperature of which was not ascertained, the sparks would fire an explosive mixture of gas and air. It was unsafe to place an unprotected motor in an explosive mixture: and he did not think that under the ordinary mining regulations such an absurdity would ever happen, but it by no means followed that even in fiery mines a properly arranged motor should not be installed. He, personally, was inclined to lay the utmost stress on the necessity of providing ample ventilation by well-designed fans rather than trusting to any safety device in the motor itself. Roughly speaking, there were two main lines on which motors might be protected; first, by enclosing the whole of the armature, and secondly, by covering the commutator and brushes only. His Company was building a 25 H P. motor with an inverted commutator and internal brushes, but there would be some little difficulty in adjusting the latter, which he hoped to get over by using carbon brushes. Too much stress could not be laid on the necessity for care in selecting the cable, and on the need of good honest work in erecting and jointing. In no other class of installation did badly designed or careless work so soon tell its own tale. Speaking generally, it appeared that lead-covered cables, protected by an outer serving of braided and ozokerited hemp, were the most durable for wet pits, and should always be used in the shafts. The risks to be expected from the mains were two-fold. There was the very remote chance of an explosion, in the event of a cable being broken when transmitting energy; and there was also a possible chance of a bad "short-circuit" or "earth" causing trouble by firing timber. So far as he knew, the leakage of an electrical conductor had never caused any difficulty more serious than a short delay; and although he had seen timber charged in a pit top by a short circuit, yet there was no chance of a fire, because the electrical instruments showed immediately that a leakage had occured, and the engineer in charge was at once on the alert. Indeed, the ease with which the supply of energy was governed and noted, formed one of the chief recommendations for the use of electrical power in mines. Electrical plant really entailed less trouble than steam or air-machinery, and the men only required to get accustomed to it to appreciate its many advantages.

Prof. ARNOLD LUPTON remarked that with reference to the question of safety in the use of these machines, the mines of this country might be roughly divided into fiery and non-fiery. The non-fiery were those in which gas might perhaps be found sometimes, but ordinarily speaking it was never seen, and blowers were never heard of. In these non-fiery mines there was a great opening for the use of electric machines. Those devices might be clever, but he ventured to prophesy that in the course of the next twenty-five years those machines would not be introduced into fiery mines. Why should an electric coal-cutter or any other electric machine be used? As stated by the authors, there was this strong reason, that the work could be accomplished with one-half the power, for a great deal less capital outlay, and for a much smaller working cost. He should like to ask what evidence there was that electrical transmission of power was any more economical than compressed-air transmission of power? The authors had quoted a Paper by Mr. Daniel, which was read in 1874, but since 1874 he believed there had been some improvements in the construction of air-compressing machinery. He should like to say that because in a colliery they did not have a very economical engine, it did not follow that one could not be made. At an average colliery were they not consuming three or four times as much fuel per horse-power as they all knew to be necessary? And was it likely that if they were not very careful about economy of fuel for a steam engine they would be much more so in the case of an air-compressing engine? He did not think that the instances of want of economy in individual air-compressors and motors in a colliery were any proof of what could be done by the system. It had been said, "You can only get 20 per cent." because there were some bad examples. He would suggest that there should be a competition between the electricians and the advocates of compressed air, each working a steam engine, the power of which was to be taken to a distance of 10,000 yards, and used in lifting water to a given height. In Table II. the authors had referred to the transmission of power to a distance of 2,000 yards with a cable of seven wires, No. 16 gauge. Mr. Brain, in the Forest of Dean, had used a cable of exactly the same length of 19 wires, No.16 gauge, for the transmission of the same horse-power, and he lost 20 per cent. of the power by the friction in the main. It was true that Mr. Brain used one-half the voltage that the authors proposed. If they had 10 per cent. loss of the power put into the main they would still require a cable of 19 wires, 16 gauge. The result was that the cost would be £100 more for the cable, without any insulators or fixing, than had been stated by the authors in Table II. The cost of 4in. pipes for compressed air had been given as £700. A 3in. pipe would be ample for the horse-power delivered, and if they took off £200 from the cost of the pipe, and put £100 on the cost of electric mains, the figures would be materially altered. He had been told by a great authority that a small motor, say 2 or 3 H.P., could not be worked at much more than 100 volts. He was also told that it was

* *The Electrician*, p. 527, Vol. XXVII., Sept. 11, 1891.

† Transactions of the Midland Institute of Mining Engineers, Vol. XI., 1888, p. 347.

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impossible to take electricity any great distance in a mine at a less voltage than 500 to do the work economically. Therefore, in order to drive several small motors in the mine at a distance from the shaft, they must have a transformer, which with continuous-current electricity absorbed at least 20 per cent. of the power. How did that affect the economy of the two methods? Then there was another equally important matter. Supposing a motor or 20 motors in a mine, all driven off one set of cables charged with electricity at a constant voltage; the motor was fixed to run at a given speed, and all the gearing was so arranged. Suppose they desired to make it run at half speed; how could that be done? He had consulted a number of electricians, who said, "Put in resistance." A resistance to reduce the speed to one-half absorbed half the power, and then what became of the economy? He had nothing to say against electrical machines, and he wished them all success; but when he heard statements that were not in accordance with his own exp erience, he thoughthe was justified in asking for some further explanation.

Mr. ALBERT GROTHE said that two years ago he visited several mining camps in the Western States of America with the object of making himself acquainted with the application of electricity to mining work. In Virginia City, Nevada, the water which had spent its energy in driving a silver mill was taken through pipes down a shaft which communicated with the great Sutro Tunnel, and was made to act through ½in. nozzles, with a head of 1,630ft. upon six Pelton water-wheels of 40in. diameter, and each connected with a dynamo. The electricity thus generated at the bottom of the shaft was conveyed back to the mill on the surface, where it drove six electric motors of 60 H.P. each at a nominal expense, thus saving 360 H.P. which formerly was absolutely wasted. At Aspen, Colorado, there was at that time only a small plant consisting of several hoisting engines driven by two dynamos of 27 H.P. It worked so well that large additions had since been made, and there were now three dynamos for sixty arc-lights each, four others supplying an aggregate of 2,500 incandescent lights, and two power dynamos, one requiring about 60 and the other 120 H.P. These drove several motors at a distance of about two miles at points underground to which it would have been most inconvenient to convey power by the older methods of transmission.

Mr. EMERSON BAINBRIDGE said the immediate point before them was the comparison instituted by the authors between compressed air and electricity. They had, however, gone a little further, and had become exponents of a certain mode of cutting coal by machinery. He was now cutting about 1,000 tons per day by machinery, and therefore had some experience in that direction. Prof. Lupton had spoken of a colliery manager being naturally disinclined to apply electricity underground in places where there was any chance of danger. Absolute security was therefore wanted in regard to sparking before a mining engineer would be justified in adopting electrical machinery in a fiery mine. His firm was using compressed air, but he did not agree with Prof. Lupton as to the comparative economy of the two systems. Mr. Snell's experience at a colliery in Yorkshire was important, because it supplied a comparison between two modes of doing the same work; and even if the compressed air machinery in that case had been badly managed, and the economy mentioned by Mr. Snell were much reduced, it would still be considerable. There was often a great mistake made as to the importance of what was called the percentage of useful effect. He supposed that the authors meant the work done as compared with the I.H.P. of the driving engine. In coal-cutting the power exerted by each machine was 6 or 8 H.P., and if with compressed air 23 H.P. was required to yield this amount, whereas with electricity 12 H.P. might suffice, the difference in cost, with a well-arranged engine, would not exceed £30 or £40 a year, which was not worth considering in comparison with the risk of stoppages and accidents underground. In the case of compressed air there was an almost perfect freedom from the risk of stoppage, which was a matter of great importance in a colliery. Although the useful effect might not be half so good with compressed air as with electrical machinery, fewer repairs would be required. If a colliery manager could have the assurance of being able to carry on his electric work without an electrician, he would be much more inclined to use these machines than he was at present. Whatever might be said about the difficulties of applying electricity to coal-cutting would not apply in the same sense to pumping. As a general rule, a pump was fixed for a longer or shorter period, but a coal-cutting machine was constantly being moved about, and there was the risk of dirt and dust flying about, and damaging the machinery and the various parts of the gear which carried the electric current, especially where several hundred yards had to be traversed. In the case of pumping there could be no comparison between the cost of compressed air and electricity. In a few days he should have a pump raising 50 gallons a minute 400ft. high at a distance of 2¼ miles from the engine; and the first cost would be less than one-half that of compressed air.

Mr. THOMAS PARKER (of Wolverhampton) remarked that as the authors had referred to the plant at the Trafalgar Colliery, with regard to which exact data were to hand, some few statements respecting it might be of interest. The first installation was put down in 1883 by Messrs. Siemens. It was only 1½ H.P, but the colliery manager was so favourably impressed with it that in 1885 an order was given to Messrs. Elwell-Parker to put down 2½ H.P. plant. That machine ran until 1887, at which date an order was given for a 20 H.P. motor in addition. That was used for pumping, and there was also a small plant for ventilating. The distance was 2,000 yards, and although the motor and dynamo were manufactured five years ago, the efficiency obtained was 40 per cent. of the brake horse power in water raised, and the cost per horse-power in water raised was 0·2d. If the loss incurred in the leads was assumed to be 10 per cent., they could easily obtain at full load an efficiency of 75 per cent. of mechanical energy delivered at any point, however distant. With regard to a question asked by Prof. Lupton implying that at varying loads they were compelled to use the same amount of energy, under ordinary circumstances the electrical motor had the power of regulating the amount of energy it received by the amount of resistance which was imposed in the way of work. As one proof that compressed air was beginning to lose favour with mining engineers where they were satisfied with the safety of the application of electricity, he would state that he had just received orders from a colliery company in his neighbourhood, after careful trial on a smaller scale, to replace compressed air plant with a 60 H.P. installation for electrical transmission. With reference to the suggestion that there should be a competition to determine the merits of electricity and compressed air, he could only say that he would be glad to enter the competition at any time that might be selected. If the cables were run in iron piping, in which also the switches might be enclosed, and if that iron piping was made to carry a supply of fresh air from a safe portion of the mine into a chamber loosely covering the motor, there would be very little risk indeed if ordinary care were taken.

(To be continued.)

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *September* 26, 1891.

Institute of Electrical Engineers.—On Tuesday last was held the first autumn meeting of the American Institute of Electrical Engineers. The Paper of the evening was the discussion of the relation of the air gap and shape of the pole pieces to the performance of dynamos, by Prof. Harris J. Ryan, of Cornell University. The Paper was exceptional in character, and contained some interesting information regarding magnetic details of machines in relation to their performance. There was a brief discussion, principally by Messrs. Mailloux and Tesla. At the next meeting, October 20th, the discussion of Prof. Ryan's Paper will be carried on, and Mr. H. Ward Leonard will give a description of the method of regulation he has devised for motors, and which he employed in the exhibition of the electric hoist at the Montreal Convention of the National Electric Light Association. I am not at liberty, on account of the foreign patents, to state the exact character of the means taken to secure the desired end; but the result is excellent, although it is attained at the cost of operating dynamo and motor as a single dynamical unit, thereby rendering it inconvenient unless a considerable amount of power is used where the output required is great enough to justify the cost. Mr. Leonard's plan of regulation is ideal in its flexibility.

A New Railway Motor.—The Thomson-Houston Electric Company is about bringing out a new style of railway motor, an iron-clad with a very powerful gramme armature, intended for low-speed work. The motor is designed with special reference to the compactness of form desirable where motors are to be applied to narrow gauge roads. Its efficiency is said to be exceedingly satisfactory, and the design was made with special reference to securing a good speed curve, so as to attain a high average efficiency as well as a high maximum. Some new wrinkles in the methods of supporting the motor on the truck are promised at an early date.

Accumulator Traction.—The Waddell-Entz storage car, of which I wrote you some time since, has been undergoing a series of trials, and has operated on the whole very successfully; but I am informed by those who have been examining its performance somewhat critically that the batteries show a tendency towards irreversible action and disintegration when discharged at a high current density, so that it is a little early yet to give anything more than a qualified endorsement to the system.

Accident on Electric Railway.—A serious accident occurred recently on the St. Paul and Minneapolis electric line; a car running at high speed jumped the track, and four persons were killed besides seriously injuring others. The managers of that line unwisely attempted to go to speeds as high as 25 miles per hour with single truck cars having 6ft. wheel bases. Some of these are equipped with motors arranged to run in parallel at high speed after passing out of the thickly settled portions of the cities, and so arranged as to run in series at a comparatively low speed when well inside the city limits. A short wheel-base and an 18ft. car, at such speeds as were attempted, resulted in a very serious amount of oscillation, so great indeed that it is a wonder that such an accident has not happened before. The result will probably be that double truck cars will be used in future, thereby obviating all danger of a repetition of a casualty of so serious a kind.

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TRADE NOTES AND NOTICES.

TENDERS WANTED.—Tenders are invited by the Postmaster-General for the supply of red fir telegraph poles, to be delivered in London, King's Lynn, or Sutton Bridge ; and at Northumberland Dock (River Tyne), West Hartlepool, Hull, or Grimsby. Tenders are also invited for creosoting the above-mentioned poles with either 10lb. or 12lb. of creosote to the cubic foot, as may be decided. Tenders may be submitted for either (A) the supply of the poles ; (B) both the supply and creosoting ; or (C) the creosoting only ; but, if B be tendered for, tenders for A and C should also be submitted. Further information will be found in our advertisement columns ; and forms of tender, containing all particulars, may be obtained on application to Mr. Charles E. Stuart, Controller of Stores, Telegraph-street, London, E.C., by whom tenders will be received until noon on Friday, October 30, 1891.

——— The London General Omnibus Company (Limited) invite proposals for the supply of sixty electric hand lamps. Proposals are to be sent to the Managing Director, 6, Finsbury-square, E.C. See advertisement columns.

SOFIA.—In a recent issue we mentioned that the tender of Messrs. Ganz and Co. had been accepted for the lighting of Sofia by electricity. The lowest tenders were as follows :—Overhead wiring : Ganz and Co., £76,400 ; Seimens and Halske, £95,500 ; Compagnie Continentale Edison, £126,800. Underground mains : Ganz and Co., £96,900 ; Crompton and Co., £123,000 ; Siemens and Halske, £124,000 ; Schuckert and Co., £135,000.

PARTNERSHIP. — Mr. Morgan Williams, formerly installation engineer to the Electrical Power Storage Company and the Electric Construction Corporation, has now entered into partnership with Mr. Frank King, and the firm are practising as consulting electrical engineers, under the title of Messrs. Morgan Williams and King, at 39, Victoria-street, Westminster, S.W.

DISSOLUTIONS OF PARTNERSHIP.—Messrs. Bennett, Hides, and Colley, trading as the Midland Electric and Telephone Company, Haxworth-chambers, Fig Tree-lane, Sheffield, electricians.—Messrs. Coveney Brothers, 67, King-street, Ramsgate, manufacturing electricians.

LONDON ELECTRIC WIRE COMPANY.—This Company have made arrangements by which all high-conductivity copper supplied by them will in future have a minimum electrical conductivity of 100 per cent. of that of pure copper, according to Matthieson's standard. Having of late years greatly increased and improved their machinery, the Company are now in an exceptional position for supplying large quantities of covered wires of any gauge at short notice.

MESSRS. J. H. HOLMES AND CO.—An electric light installation has just been put in operation by this firm at the Tarbrax Works of the Caledonian Oil Company.

HOSPITAL LIGHTING.—The St. George's Hospital Committee have decided to avail themselves of the electric current from the supply mains for electric lighting the operating theatre, &c. ; also for cautery purposes. The work has been entrusted to Messrs. Drake and Gorham, who have designed complete arrangements to meet all the special requirements.

THE MINING AND GENERAL ELECTRIC LAMP COMPANY (LIMITED). —This Company are issuing particulars of their various specialities, including their electric safety lamps and storage batteries. The Company are sole manufacturers of "Lithanode," and accumulators under the patents of Fitzgerald, Frankland, and others, and are manufacturers of general accumulator accessories.

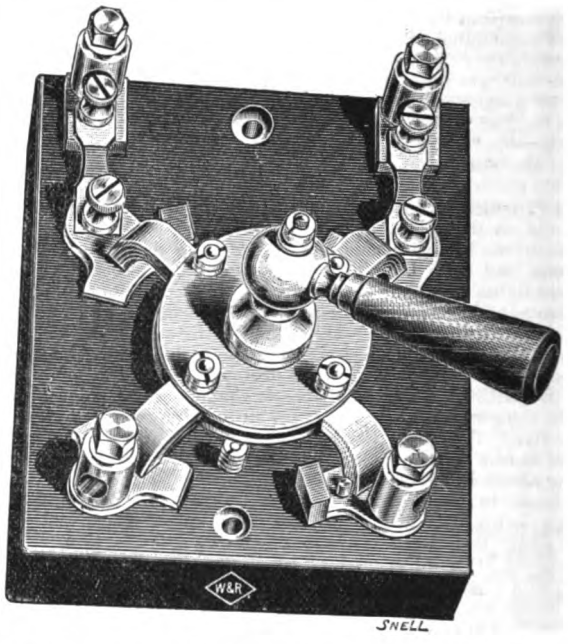
THE NEW YORK INSULATED WIRE COMPANY.—We have received from this Company a neatly-printed *brochure*, giving fully illustrated particulars of their distributing main-line cut-outs, junction boxes, angle boxes, conduits, &c.

INSTITUTE OF MEDICAL ELECTRICITY (LIMITED).—It was resolved at a meeting on September 15th, and the resolution was confirmed at a further meeting on October 1st, that the Institute be voluntarily wound up ; and that Mr. John W. Biggs, 12, Delahay-street, Westminster, be liquidator. Claims are to be sent in to the liquidator by October 31st. We much regret the enforced stoppage of this useful institution, which failed to receive support from the medical profession. It may be the Institute will be resuscitated in a modified form later.

MESSRS. JOHNSON AND PHILLIPS.—This firm informs us that they are extremely busy in their manufacturing departments, and that, in particular, they have heavy orders on hand for their arc lamps.

ELECTRICAL ENGINEERING CORPORATION, LIMITED (IN LIQUIDATION).—Replying to a letter recently addressed to him, Mr. F. W. Pixley, the receiver and manager of this concern, says : "I am now realising the assets of this Corporation, which, however, I regret to say will hardly be sufficient to pay the debenture holders, and there will therefore in all probability be no dividend for ordinary creditors." This is cheering news for the numerous creditors of the defunct Corporation.

A DOUBLE POLE SWITCH.—The practice of placing switches in both paths of an electric lighting circuit, especially at the entrance to buildings which are supplied with electric current from central-station supply mains, is recommended by some authorities, and is condemned by others on account of the proximity of the base metal conductors. When switches are thus arranged the current may be shut off from all contact with the house wires, except when the lamps are actually burning, thus lessening the risk of leakage, and the possibility of damage to the insulation. Messrs. Woodhouse and Rawson United (Limited) have lately introduced types of double pole switches which combine on one base and with one movement the action of two separate ordinary switches. Our illustration shows the form given to those intended for ordinary electromotive forces. It is "quick-break," the handle is fitted loosely, and



powerful springs come into play and break both circuits simultaneously. Great care is taken to insulate the two circuits completely from one another.

MESSRS. WOODHOUSE AND RAWSON UNITED (LIMITED).—We have received a copy of List B, just issued by this firm. The book relates to measuring instruments, &c. ; is admirably printed, and contains a mass of useful information.

NEW COMPANIES, STATUTORY RETURNS, &c.

ABERCARNE ENGINEERING AND FOUNDRY COMPANY (LIMITED). This Company has been registered with a capital of £15,000, in £5 shares, to acquire the undertaking of an ironfounder and manufacturer, now carried on by Jesse Bailey, at Abercarne, near Newport, Monmouthshire, in accordance with an agreement made between Jesse Bailey of the one part and John Moxon of the other part, and to carry on in all its branches the business of steel and iron founders, mechanical engineers, &c.

RICHARD S. HUGHES (LIMITED).—This Company was registered on October 3, 1891, with a capital of £15,000, in £10 shares (for private subscription only), by Thomsons, Brooks, and Danby, solicitors, 63, Cornhill, E.C. The objects are to acquire the goodwill of, and take over as a going concern, the business carried on by R. S. Hughes at 95, 96, and 97, Hatton-garden and Robin Hood-yard, E.C., to adopt an agreement for the purpose, and to carry on the business of gas and electrical engineers and fitters, manufacturers of gasaliers, chandeliers, electroliers, and of gas and electric lighting fittings and appliances, lamp-makers, &c. The number of Directors is not to be more than four, the first being Richard S. Hughes and Fleetwood Stileman for twelve years after the registration of the Company. So long as Mr. Hughes holds one-third of the original capital of the Company he may appoint other Directors, but so that the number does not exceed four. Remuneration £250 per annum for each of the above or two years, but that of F. Stileman will be increased to £300 after hat time. Secretary and office : D. J. Sadler, 96, Hatton-garden.

BYNG TELEPHONE COMPANY (LIMITED).—The following notice from J. P. Spencer, of 32, Moseley-street, Newcastle-on-Tyne, the liquidator of the above Company, was filed on October 2, 1891 :—"To the Registrar of Joint Stock Companies. I beg to inform you that a general meeting of the above-named Company was held on September 17th, for the purpose of having an account laid before it, showing the manner in which the winding up of the said Company had been conducted, and its property disposed of, and of hearing any explanation that might be given by the

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liquidator. I have further to inform you that the notice calling the meeting was duly published in the *London Gazette* of August 14, 1891, and that a circular notice thereof was also sent to each member, together with a copy of the liquidator's report and a copy of the statement of accounts." The above Company was registered on February 25, 1886, with a capital of £5,000 in £10 shares.

"ECLIPSE" ELECTRIC LIGHTING SYNDICATE (LIMITED).—The offices of this Company have been removed from 18, Telegraph-street, E.C., to 2, Pancras-lane, Queen-street, London, E.C. (Filed on October 3rd, 1891.)

ELECTRIC WELDING COMPANY (LIMITED).—The registered office of this Company has been removed from 3, Tokenhouse-buildings to 2, Tokenhouse-buildings, E.C.

LAING, WHARTON, AND DOWN CONSTRUCTION SYNDICATE (LIMITED). The following special resolution was passed July 27, 1891, confirmed August 12th, and a notice filed August 22nd:—"That the capital of the Company be increased to £100,000, of which not more than £30,000 may be issued at the discretion of the Directors in shares to be called preference shares, and to carry a fixed preferential dividend, at the rate of £5 per cent. per annum." The annual return, made up to August 10, 1891, was filed on September 8th. The nominal capital is £40,000, in £100 shares, of which 399 have been taken up, the full amount called and paid on 266, and the remainder considered as fully paid. Office: 82A, New Bond-street.

LIVERPOOL AND DISTRICT PULSION TELEPHONE COMPANY (LIMITED). The statutory return of this Company, made up to July 8, 1891, was filed on the 14th following. The Company, which was registered on March 5, 1891, has a capital of £6,100, divided into 6,000 ordinary and 100 founders' shares of £1 each. 4,080 of the ordinary and the founders' shares have been taken up, and upon 1,080 of the ordinary shares 5s. per share has been called, and £257. 10s. paid, leaving £12. 10s. unpaid. The remaining shares (*i.e.*, the founders' and 3,000 of the ordinary shares) are considered as fully paid. The Company holds a licence from the Primary Syndicate (Limited), for the exclusive use, within 20 miles from the Town Hall of Liverpool, of Patent No. 8,457 of 1888, in respect of an invention for "improvements in mechanical telephones," and in full satisfaction for such licence 3,000 ordinary and 100 founders' shares in this Company were allotted to the Primary Syndicate or its nominees. Office: C, Queen Insurance-buildings, Liverpool.

MAITLAND AND COMPANY, LIMITED (Commission Agents, Contractors for Railways, Telegraphs, Telephones, Electric Light, Heat, and Power Works, &c., in China).—The annual return of this Company, made up to October 1, 1891, was filed on the following day. The Company, which was registered on May 3, 1890, has a nominal capital of £10,000, in £100 shares. All the shares have been taken up, and £5 per share has been called and paid. Messrs. Thorne and Co. (Limited), of 66, Old Broad-street, E.C., hold 93 of the shares. Office: 66, Old Broad-street, E.C.

NATIONAL TELEPHONE COMPANY (LIMITED).—The annual return of this Company, made up to June 30, 1891, was filed on September 29th. The nominal capital is £4,000,000, divided into 30,000 preference shares of £10 each, and 740,000 ordinary shares of £5 each; 30,000 preference and 447,234 of the ordinary shares have been taken up and the full amount called. All the calls have been paid, amounting to £2,536,170.

W. T. HENLEY'S TELEGRAPH WORKS COMPANY (LIMITED).—The annual return of this Company, made up to September 1, 1891, was filed on the 21st following. The Company, which was registered on February 21, 1880, has a capital of £70,000, in £10 shares, 6,697 of these have been taken up, the full amount called, and £66,700 paid, leaving £270 unpaid. Office: 27, Martin's-lane, E.C.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).—The accounts of this Company, subject to audit, show a profit sufficient to enable the Directors to recommend a final dividend of 1s. per share, making, with previous distributions, a total dividend of 6 per cent. for the year ended June 30, 1891, and also the payment of a bonus of 4s. per share, both free of income-tax, which together will amount to £32,500, leaving a balance of £88,210. 16s. 9d., of which amount £60,000 has been placed to the reserve fund, increasing that fund to £474,878. 7s., and £28,210. 16s. 9d. carried forward. The very exceptional increase in revenue mainly arises from the disturbed state of affairs in South America. For the purpose of paying the above dividend and bonus on the 22nd inst. the register of transfers will be closed from the 12th to the 21st inst., both days inclusive. The traffic receipts for the week ended October 2nd were £5,226.

CITY AND SOUTH LONDON RAILWAY COMPANY.—The traffic receipts of this Company for the week ended October 4th amounted to £748; aggregate receipts for half-year to date, £9,663.

CITY OF LONDON ELECTRIC LIGHTING COMPANY.—Colonel Ben Hay Martindale, C.B., has been elected a Director of this Company. Application has been made to the Stock Exchange Committee to appoint a special settling day in, and to grant a quotation to, the ordinary shares.

CITY OF LONDON ELECTRIC LIGHTING (PIONEER) COMPANY (LIMITED).—Notice is given, that an extraordinary general meeting of this Company will be held at Winchester House, Old Broad-street, E.C., at 2.30 p.m., on Tuesday, the 20th inst., when the subjoined resolution, which was passed at the extraordinary general meeting of the Company held on the 30th ult., will be submitted for confirmation as a special resolution:—"That the Company be wound up voluntarily." Should the resolution be confirmed, a further resolution will be proposed at the same meeting for the appointment of the Hon. Alan Charteris and Mr. Joseph Cecil Bull to be liquidators for the purposes of such winding up and for fixing their remuneration.

CUBA SUBMARINE TELEGRAPH COMPANY.—The estimated traffic receipts of this Company for the month of September were £3,000, as compared with £2,997 in the corresponding month of last year.

DIRECT SPANISH TELEGRAPH COMPANY.—The traffic receipts of this Company for the month of September were £2,004, as compared with £2,526 in the corresponding period of last year, a decrease of £522.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this Company for the month of September, 1891, amounted to £56,589, and to £55,346 in the corresponding period of 1890, an increase of £1,243.

EASTERN EXTENSION TELEGRAPH COMPANY.—The receipts of this Company for September amounted to £40,586, as against £43,938 in the corresponding period of last year, showing a decrease of £3,352.

ELECTRIC CONSTRUCTION CORPORATION.—Mr. W. W. Duncan, in his October circular, after referring to the fact that the price of the ordinary shares of the Brush Electrical Engineering Company has risen to a premium of about 15 per cent., and calling the attention of investors to the value of the Electric Construction Corporation shares as an investment, makes the following remarks on the financial position of this Company:—"The Electric Construction Corporation has for its Chairman Sir Henry Mance, who is one of the most experienced electricians in the country, and has for its manager Mr. Thomas Parker, who as a practical electrician is second to no one. Let us, however, judge the position of the Corporation by actual practical results. The accounts for the first year's working were made up to September 30, 1890, with the following results:—A net profit of £56,640, which enabled the Directors to write off the preliminary expenses (£4,350), and to pay a dividend of 6 per cent. upon the shares for the year, after carrying £15,000 to reserve. I understand that the profits of the year just closed will show considerably better results, although I would not like to anticipate a higher dividend than 6 per cent., as I believe it is the policy of the Directors to build up a large reserve fund. The report will be issued and the dividend paid in the course of next month; but, meantime, the shares can be bought cum dividend at about 40 per cent. discount. The only reason I can assign for the remarkable cheapness of these shares is that some of the larger shareholders were, owing to the recent financial crisis, obliged to realise at a time when there were very few buyers about. The Company's works are fully employed, and it has some very important and valuable contracts on hand, among which is the application of electric traction to the Liverpool Overhead Railway and the South Staffordshire Tramway Company. This Corporation and its affiliated Company, the Electric Traction Company, are ahead of all other construction companies in the immense field which is opening up for electric traction, and some of the most important provincial tramways, notably the Glasgow Tramway, are in close negotiation for the application to their systems. Instead of these shares being at a discount, in my opinion, with the undoubted future before the Corporation in the manufacture of both electric lighting and electric traction appliances, they ought to be at a considerable premium. I maintain that the field for profitable enterprise covered by this Corporation is greater far than it ever was in the case of telegraphy, and that there is every ground, therefore, for believing that it will meet with at least equal success."

EUROPEAN SIMS-EDISON ELECTRICAL TORPEDO COMPANY (LIMITED). The prospectus of this Company was issued early this week. The Company is formed with a capital of £201,000, divided into 10,000 ordinary shares of £20 each (first entitled to all profits up to 10 per cent. per annum, and half the surplus profits) and 1,000 founders' shares of £1 each (subscribed for by the vendors, and entitled to the balance half of the surplus profits). Included in the directorate are Mr. John L. Martin, one of the Directors of the International Okonite Company; M. Albert Ellissen, a Director of the Compagnie Continentale Edison, Paris; Everett Frazer, President, and W. Scott Sims, General Manager of the Sims-Edison Electric Torpedo Company of New York. The chief engineer is Mr. W. Scott Sims; consulting electrical engineer, Mr. T. A. Edison. The offices of the Company are at No. 9, Fenchurch-avenue, London, E.C.; 3, Rue Vignon, Paris; and the secretary (*pro tem.*) is Mr. Henry Shaw. The Company is formed (so the prospectus states) to work the inventions relating to the Sims-Edison Electrical Torpedo for the whole of Europe, India, and the British Colonies. The following are among the advantages claimed for this torpedo:—1. An effective range of two miles, at a rate of speed of over 20 knots. 2. Instant control from a distance by electricity as to starting, stopping, steering, and exploding. 3. Invulnerability to the shot or shell of the enemy, all but the float being under water. 4. Absolute reliability in operation. 5. The power to dive under or cut through obstructions placed in its path. 6. Capacity to carry a charge of 500lb. of the highest explosive, sufficient to disable, if not destroy, the largest warship, even if it exploded 30ft. distant, which is about the limit of netting defence. The Government of the United States of America, after an exhaustive series of official tests, have adopted this torpedo and purchased several, and more are now being constructed under contract for that Government. The Société des Forges et Chantiers de la Mediterranée has contracted for their manufacture for France, Russia, Austria, Belgium, Spain, Greece, and certain other Continental countries on terms which the Directors believe to be very favourable for this Company. Messrs. Sir W. G. Armstrong, Mitchell and Co. (Limited), have expressed their willingness to contract on similar terms for the United Kingdom, the Colonies, and Italy; and negotiations are pending with the Vulcan Works of Stettin, Germany, for the Empire of Germany. The Directors feel a

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difficulty in stating publicly the estimated profits on these torpedoes, but even on a moderate amount of business anticipate highly satisfactory dividends to the shareholders. The electrical mechanism employed in the Sims-Edison torpedo, by which it can be propelled at high speed with great force through the water and steered from the shore, is also applicable to lifeboat service. We must refer our readers to the full prospectus for further particulars. The subscription lists opened on Monday and closed on Wednesday last.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of this Company in September, 1891, were £24.000; January 1st to September 30th, £213,400; corresponding period, 1890, £206,800; corresponding period, 1889, £203,200.

INTERNATIONAL OKONITE COMPANY (LIMITED)—The first annual general meeting of this Company has been postponed from Friday, October 9th (to-day), and will be now held on Wednesday, October 14th prox., at noon, at the Cannon-street Hotel, City of London.

NATIONAL TELEPHONE COMPANY (LIMITED).—The Directors have made a new issue of 4½ per cent. debentures to provide capital for further extensions and improvements of the system. The issue was offered to the present shareholders at £105 for each £100, and it has been largely over applied for.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The traffic receipts of this Company for the month ended September 30th were £3,650.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended October 2nd, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £4,100.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The traffic receipts of this Company for the half-month to September 30th were £1,598, as compared with £2,438 in the corresponding period of last year.

WINFIELDS (LIMITED).—At a meeting of the shareholders of this Company held on the 2nd inst., the Chairman, in moving the annual report, stated that all the profits of the year had been required in the business, and that he was much disappointed with the result of the year's trading. During the first six months of the past year trade had been fairly good, but the latter half of the year had been bad. The Directors were modernising the plant and means of production.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Sept. 30.	Price Wednesday, Oct. 7.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Oct. 7. Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
£1,300,980	Stock	12/0	Anglo-American	48 49	48½ 49½	5 1 0	Jan., Apr., July, Oct.	49½	48½
£2,849,510	Stock	24/0	Do. Preferred	87 88	87½ 88½	5 15 10	" "	88½	87½
£2,849,510	Stock	5/0	Do. Deferred	13 13½	12½ 13½	..	.. ..	13⅝	12⅝
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99 102	99 102	3 18 5	January and July	..	..
130,000	£10	5/0	Brazilian Submarine	11½ 12½	12 12½	6 16 0	Mar., June, Oct., Dec.	12½	12
£69,200	£100	5%	Do. 5 per Cent. Bonds	99 102	99 102	4 18 0	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107	103 107	4 13 6	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock xd	122 124	122 124	5 8 10	April and October	124½	123
16,000	10	8/0	Cuba Submarine	10½ 11½	10½ 11½	6 19 2	February and August	11 7/8	11
6,000	10	10%	Do. Preference 10%	17 18	17 18	5 11 1	" "	..	..
12,931	5	2/0	Direct Spanish (£4 paid) xd	3½ 4	3½ 4	7 0 0	April and October	..	..
6,000	5	10%	Do. Preference 10% xd	9 10	9½ 10½	4 15 3	" "	10	9⅝
60,710	20	3/6	Direct United States	10⅞ 11½	11 11½	6 4 5	Jan., Apr., July, Oct.	11½	10⅝
400,000	10	5/6	Eastern	14⅛ 14⅜	14¼ 14½	4 9 8	" "	14 7/8	14¼
70,000	10	6%	Do. 6 per Cent. Preference	15 15½	15 15⅜	3 17 5	" "	15⅜	15¼
£1,200,000	Stock	6%	Do. 4 per Cent. Mort. Debenture Stock	107 110	107 110	3 12 9	May and November	109½	108⅜
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	107 110	4 10 11	February & August	..	..
250,000	10	2/6	Eastern Extension	14⅞ 15⅛	14⅞ 15⅛	4 12 7	Jan., Apr., July, Oct.	15⅛	15
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock	106 109	106 109	3 13 5	February & August	..	..
£85,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	104 107	104 107	4 13 6	January and July	105	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	102 105	102 105	4 15 3	" "	..	..
180,227	10	4/6	Globe Telegraph and Trust	9⅝ 9⅞	9⅝ 10	5 7 6	Jan., Apr., July, Oct.	9⅞	9⅝
180,042	10	6%	Do. 6 per Cent. Preference	14⅞ 15⅛	14⅞ 15⅛	3 19 4	" "	15⅛	14⅞
150,000	10	5/0	Great Northern	18⅞ 19⅛	18⅞ 19⅛	4 8 4	Jan., April, and July	18⅞	18⅝
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	104 107	104 107	4 13 6	March & September	..	..
17,000	25	37/6	Indo-European	41 43	41 43	5 15 3	May and November	..	..
38,348	10	5/0	London Platino-Brazilian	6½ 7½	6½ 7½	6 0 0	" "	7½	—
£100,000	100	6%	Do. 6 per Cent. Debentures	105 108	105 108	5 11 1	March & September	107	..
9,000	8	4/0	Reuter's	8 8½	8 8½	4 14 1	April and October	..	..
3,381	£100 Cert.	£1	Submarine Cables Trust 6%	120 125	120 125	4 16 0	" "	120½	..
15,609	10	6/0	West African Telegraph	8 9	7½ 8½	5 17 8	January and July	8	..
£281,400	100	5%	Do. 5 per Cent. Debentures	96 99	97 100	5 0 0	March & September	99½	..
30,000	10	2/0	West Coast of America	3⅜ 4½	3⅜ 4½	..	January and July	..	..
£150,000	100	8%	Do. Debentures 8% 1902	98 103	98 103	7 15 4	June and December	..	..
88,321	10	9d.	West India and Panama	1⅝ 1⅞	1⅝ 1⅝	..	..	1⅞	1 7/8
34,563	10	6%	Do. 6 per Cent. 1st Preference	9½ 10	9½ 9⅝	6 3 1	May and November	9 1/16	9½
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8 9	8 9	6 13 4	" "	..	..
61,653	15	9/0	Western and Brazilian	10⅜ 11⅛	10⅜ 11⅛	6 13 4	" "	11⅛	11
30,364	7½	1/6	Do 5 per Cent. Cumulative Preferred	6¾ 7	6¾ 7	5 7 3	—	7	6⅞
30,364	7½	7/6	Do. 5 per Cent. Deferred	4½ 4⅝	4⅝ 5	..	..	4 1/16	4 1/16
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	102 105	102 105	5 14 3	February & August	..	—
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	102 105	102 105	5 14 3	" "	..	—
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	120 125	120 125	5 12 0	May and November	..	—
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	98 102	98 102	5 17 8	March & September	..	—
			TELEPHONES.						
224,850	14/0	0/5½	Consolidated Telephone Const. & Maintenance	7/16 9/16	7/16 9/16	..	May and November	⅛	—
220,000	£1	4·76d.	Oriental (11s. paid)	1 1/16 1 3/16	1 1/16 1 3/16	6 8 11	Yearly	..	..
438,984	5	3/6	National	4⅜ 4⅝	4⅜ 4⅝	6 9 9	June and December	4 1/16	4⅜
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½ 13	12½ 13	4 12 4	" "	..	..
15,000	10	6%	Do 6 per Cent. Cumulative 2nd Pref. (£8 pd)	12½ 13	12 13	3 14 1	" "	..	..
350,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd)	106 107	105 107	4 4 1	.. ..	106¾	105¾
58,000	5	1/0	United River Plate	2 3	2 3	..	January and July	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85 95	85 95	5 5 8	—	..	..
			ELECTRICITY SUPPLY COMPANIES.						
1,000	£10	..	City of London Electric Lighting (£4 paid, £10 Sh.)	..	4⅛ 4⅜	..	..	..	—
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	—
5,322	£5	..	House to House Electric	..	4½ 5	..	..	..	—
30,000	£5	..	Liverpool Electric Supply (£3 paid)	..	4⅝ 5⅛	..	..	..	—
111,000	5	..	London Electric Supply	2⅛ 2⅜	2 2⅛	..	..	..	—
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	10 10½	10 10½	..	..	10⅜	..
7,730	£5	3/6	St. James' and Pall Mall	8 8½	8 8½	—	..	8⅜	8⅛
..	..	7%	Do. 7% Preference	4⅜ 5⅛	6⅜ 7⅛	—	..	7 1/16	7
42,853	5	..	Westminster Electric Supply (£5 paid)	5⅛ 6⅛	5⅛ 6⅛	..	..	6 1/16	5⅞
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
77,978		1/8	Brush Electrical Engineering xd	3½ 3⅝	3⅜ 3⅝	5 6 8	..	3⅛	3 1/16
69,996		6%	Do. 6 per Cent. Preference xd	1⅞ 2	1⅝ 2⅛	5 12 11	June and December	2⅛	1⅞
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5 5½	5 5½	6 7 3	January and July	—	—
17,180	5	..	Edison and Swan United	.. ..	.. ..	..	—	..	..
45,000	10	6%	Electric Construction	6 6½	7 7½	..	—	7⅜	6 7/16
70,000	2	10/0	Elmore's Patent Copper Depositing	3⅞ 4⅛	3⅞ 4⅛	..	—	4	..
20,000	5	..	Fowler-Waring Cables (£4 paid)	2 3	2 3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	20 21	20 21	4 15 3	February & August	20⅜	20
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	March & September	..	..
11,334	£10	6/1	International Okonite Limited Ordinary	7 8	7 8	..	..	..	..
11,334	£10	5/0	Do. Preference	9 9½	9 9½	8 8 9	..	..	..
78,949	5	2/1½	Swan United (£3. 10s. paid)	5 5½	5 5½	6 7 5	May and November	5½	5½
37,350	12	12/0	Telegraph Construction and Maintenance	42 44	42 44	5 9 3	March and July	43½	42½
50,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	102 105	102 105	4 15 3	January and July	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£2. 10s. paid)	..	2½ 2⅝	..	..	..	..
—	£5	..	Do. Preference (fully paid)	..	3⅜ 4	..	..	..	..
			RAILWAYS.						
50,000	£10	..	City and South London Railway	4	2 4	—	—	—	—

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THE ELECTRICIAN:

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NOTES.

The Annual Report of the Post Office for 1890-91 just issued, and signed by the late Postmaster-General, gives, as usual, some interesting figures relating to the Telegraph Service. Business, it appears, continues to increase, but not at the same rate as formerly; whilst the average value of each transaction has a slight tendency to diminish. This latter fact may be due to an increase in the number of short business messages; or it may be to increased expertness of private senders in the practice of brevity. Any way the result is the same, the increase in receipts for the year being less than it has been since 1886-87. Mr. Raikes ascribes the falling off in the normal increase of messages to the increasing use of the telephone, not only in the metropolis but throughout the provinces. It is, perhaps, as well that this admission should be publicly made just now, though it comes rather late. The Post Office on the one hand and the Telephone Companies on the other, each for reasons of their own, have maintained until now a conspiracy of silence on this delicate point. One would be curious to know what proportion the Telephone Companies' royalties bear to the estimated loss of public revenue traceable to this licensed competition with the State Telegraphs.

More pointed allusion is made to a still greater loss of revenue through what may be justly termed the shameless abuse of the free railway message privileges. It is not the first time Mr. Raikes has referred to it with evident chagrin. This year the ugly fact is displayed with conspicuous particularity, a short table showing on page 11 the number of messages of various kinds for the past two years and the money derived from them. Opposite the item, Railway Telegrams, we have, for 1890-91, 1,535,067; for 1889-90, 1,291,788; increase, 243,279; Receipts, Nil. The plain English of this is that the burden of free telegrams, which the railway companies contrived to impose at the time of the transfer, and which at that period was quite insignificant, has assumed the enormous proportions above stated, and is now increasing at the rate of a quarter of a million messages a year. Mr. Raikes estimates the value of these franked telegrams at no less than £76,500 per annum—a moderate estimate we fancy, as there is no restriction as to the quantity of words these missives may contain. The number of free railway messages during the first year of the concession was only 116,000. Its increase since that period can be described only in the terms we have employed above.

The daily papers have been occupied of late with the provincial orations of our leading politicians. We read, or do not read, as the case may be, the verbatim reports of these speeches within a few hours of their delivery, and give hardly a thought to the careful organisation and hard work that they entail. The papers send down their reporters, and while these are still at work the copy begins to be handed in in Fleet-street. This is taken so much as a matter of course that they forget to put "by telegraph;" and the space being reserved (the eminence of each member of Parliament being estimated at so many columns), there would be a great outcry if the Post Office were to fail in transmitting these messages. But for the alacrity of the Post Office officials in South Wales, no reports of Mr. Chamberlain's recent speech would have been forthcoming on Wednesday morning; and as his remarks were probably intended to reach a wider audience than that which was actually before him, he might have been tempted to curb his eloquence had he known that the storm had interrupted all telegraphic communication between South Wales and London. But the Post Office was equal to the occasion; and the lines to Chester, Liverpool, and Preston were connected and put through to London, and the speech was sent by that route with Wheatstone automatic instruments.

The explanation of a phenomenon, the existence of which is doubtful; the description of a method of investigation, which has not yet been tried; and a negative result of a series of experiments; have a purely scientific interest which "the practical man" will often fail to appreciate. The explanation will be thrown away if the phenomenon turns out to be imaginary; the method may prove to be illusory; and two negative results need not necessarily produce a positive one. We therefore wait until Prof. Ewing satisfies us as to the first two of these points, and in the meantime note the communication of Messrs. Evershed and Vignoles which bears on the same subject. On the appearance in these columns of an article by Mr. Kennelly (*The Electrician*, Vol. XXV.) on "Permeability of Iron at Right Angles to the Direction of Magnetisation," Messrs. Evershed and Vignoles contributed an account of some experiments on cross-magnetisation, in which they showed that a slight transverse field "joggled out" the residual magnetism. With the view of ascertaining whether the alleged reduction of hysteresis in a loaded transformer was due to a slight cross-magnetisation produced by magnetic leakage, they have applied a transverse

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magnetisation to a small transformer in the core of which a clinical thermometer was embedded.

The result as interpreted by the authors is a negative one. We are inclined to think that it may bear a somewhat different explanation, but they promise to continue the account of their investigation. The method is worth noticing. The rate of rise of temperature and the correction can be measured with much greater accuracy than might be supposed, as is proved by the closeness with which the observations lie on the lines. One of the objections urged, last winter, to an experiment in which the heating of a transformer was measured by a thermometer, was that the temperature never became constant, by which the critics meant that they never had the patience to wait. But the present method, which occupies minutes instead of hours, and where the transit of the mercury across the divisions was read in seconds, not only makes less demand on time and patience, but enables a steady current to be maintained throughout the experiment without difficulty.

The acquisition of the telephones by the State proceeds apace on the Continent, the protracted negotiations for the purchase of the exchanges worked by the Telephone Company of Austria in some eight towns of the Empire having at last terminated. The first proposals of the Austrian Government were, we believe, of a somewhat confiscatory character; but owing, it is stated, to the intervention of the British Ambassador (the Company is mainly a product of English capital), an amount bearing some relation to the capital invested and the business done will now be paid. At the end of next year the Telephone Company of Austria will cease to exist, and its 6,000 or 7,000 subscribers will then enjoy the benefits of State management. Interurban telephony, which has attained considerable vogue of late in Austria, has always, it may be remarked in passing, been a Government enterprise, as well as several small exchanges with a total of about 1,500 subscribers.

Our New York letter this week gives a brief summary of the official report relating to the recent electrical executions at Sing Sing prison. Contrary to what was asserted at the time it now appears certain that in no case was death instantaneous, several shocks having to be administered before the ghastly jobs were finished. It is said that consciousness ceased on the first application of the current; but as respiration began to be resumed in at least one case before the second shock, this humane assertion cannot be confidently accepted.

Contradictory and erroneous accounts of the Gülcher thermopile have been circulated in various journals. We paid little attention to the invention at first, since it is handicapped by so serious difficulties; but having received several inquiries about it, we applied for information from Herr Gülcher, who has been good enough to give us some figures. These are not very encouraging, but as we are promised some further information we will postpone their publication at present.

Royal Microscopical Society.—A meeting of this Society will be held on Wednesday next at 8 p.m., when several Papers are down for reading.

Telephone Charges.—According to a correspondent of the *Scotsman* in Paisley, an exchange connection is offered for £5 per annum; and where two people use the same wire, each with their own instrument, the rate of £3 per annum each is charged.

Queenstown.—At a recent meeting of the Town Commissioners, the Clerk was instructed to write to Messrs. J. E. H. Gordon and Co., supplying them with particulars as to the area, population, and water supply, and asking them what they would light the town for.

Toynbee Hall.—A course of ten lectures will be given by Mr. A. H. Fison on Electricity, on Monday evenings, at 8 p.m., commencing October 5th. The first four lectures will deal with the principles of the science, and the remaining six will be devoted to applications. The fee for the course is one shilling.

Mica Deposits in Queensland.—A discovery has been made of mica in large quantities at a point about 25 miles west of Muldiva. The plates are of fairly good quality, are improving as the development proceeds, and are free from impurities. Four leases have been applied for, comprising an area of 100 acres.

Institution of Mechanical Engineers.—Two general meetings of the above will be held on the 28th and 29th of October, at 7.30 p.m., when a paper will be read on "Some Details of Construction of Modern Lancashire Boilers," by S. Boswell; and a report to the Alloys Research Committee will be presented by Prof. Roberts-Austen.

The Rhondda and Swansea Bay Railway.—The Directors of this railway have obtained a report from Messrs. Morgan, Williams, and King, of Victoria-street, S.W., on the question of the electric lighting of a two-mile tunnel, and also of their passenger trains. We understand it is proposed to utilise water-power for generating the current.

Lauffen-Frankfort Transmission.—We heard from our Frankfort correspondent yesterday that the transmission plant is working smoothly at 17,000 volts. A workman named Rau was killed on the 12th inst. in the transformer house at Lauffen, having entered it against the rules. He was altering a lamp. The engineer observed fluctuations in his instruments and went straight to the transformer-house, where he found the man dead.

Transmission of Power in Wurtemberg.—The plant for the transmission of 80 H.P. by electricity has been laid down at Messrs. Kutter and Co.'s paper mill, at Wolfegg. The fall from which the power is derived lies about half a mile from the mill. The wires are carried on telegraph poles to the mill, the efficiency of the transmission being 80 per cent. This work, as well as that of lighting the works, has been carried out by Messrs. Reisser, of Stuttgart.

Theatre Lighting in Portugal.—The Government has declined to continue to pay for the electric lighting of the Lisbon Opera House, which amounts to over £6,000 a year, or to contribute towards any other system of lighting. The Government never was under an obligation to pay for the lighting as it has done hitherto, and it is stated that the electric method is being found too costly, while the laying down of gas pipes would amount to a still greater sum.

An American Engineering Problem.—A short time since it became necessary to move a large building across the track of the Concord Electric Street Railway. Of course objection was made to cutting the wires, but after some consultation with the movers, Superintendent George W. Pierce concluded to try to lower the wire sufficient to pass the building over it. Although this line is constructed in the most substantial manner, it was found that releasing four or five span wires would let the wire down sufficiently. It was then planked over, and the building passed over without interruption of service.

Project for Transmission of Power in Austria.—We learn from the *Elektrotechnischer Anzeiger* that Messrs. Franz and Co, of Marburg, intend to make use of a 180 foot waterfall,

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situated at St. Lorenzen, 18 miles distant, for the purpose of running their works. The power available at the generating station will be about 600 H.P., and it is expected to utilise about 450 H.P. of this at the works, the total cost of the plant being estimated at £22,500.

Dover.—The Electric Light.—A recent meeting of the Town Council was held for the purpose of considering the tender of the Brush Electrical Engineering Company for the supply of the electric light to the borough. Since the last meeting a modified tender had been received, which provided a lesser number of lamps at a greater distance apart at a cost of £650, the first tender submitted being for £1,245. It was decided to provisionally accept the company's modified tender.

The Recent Storm.—The General Post Office gave notice on Tuesday last of considerable delay in telegraphing to all offices south and west of Exeter, Bristol, South Wales, and Ireland. Communication with the Channel Islands by the English route was totally interrupted. Several of the cables to America were also idle, owing to broken land lines. On making enquiries we learn that the breakages were all due to trees falling across the lines, no failure of posts having been reported up to yesterday morning.

Fire at the Bournemouth Telephone Exchange.—A fire occurred at the central office of the Bournemouth Telephone Office on Tuesday; and telephonic communication in Bournemouth, and with Southampton, Poole, and other places is suspended, and likely to be so for some days. The telephone officials state positively that the fire was caused by an electric light current, through contact with the top of an iron roof standard to which the electric light wires were fixed. The fire was quickly extinguished.

New Electrical Scheme in Switzerland.—An important plant is about to be laid down at the bridge between Hundwil and Herisau. A tunnel three miles long, with a fall of ·5 in 100, is to convey water from the junction of the rivers Silter and Urnach, which will furnish power to the extent of 1,200 H.P. Some of this is to be applied to working a tramway between St. Gallen, Speicher, and Trogen; and it is expected that 800 H.P. will be available for distribution for industrial purposes in the neighbourhood.

Crystal Palace, Sydenham, District.—The foundation stone of the supply station for this district will be laid on Saturday next. Messrs. J. E. H. Gordon and Co. propose to use dynamotors for transforming down the continuous high-pressure supply, in connection with storage batteries. In the first instance about 500 H.P. of electrical energy will be transmitted from the generating station to the Crystal Palace, for the purposes of the Electrical Exhibition which opens on January 1, 1892, and no time will be lost in laying the mains for supply of the consumers in the district.

Edinburgh Corporation and the Overhead Electrical System. The Lord Provost's Committee of the Edinburgh Town Council had before them a letter from Mr. R. Addison Smith, on the subject of the erection of a temporary overhead electrical system in Leith Walk, with the view of showing the Corporation and the Tramway Company that tramcars can be worked on steep grades by electricity, and also with the view of obtaining data as to the cost of driving. A report by the Burgh Engineer on the subject was read, and the committee resolved to recommend the Town Council to decline to give their sanction to the proposal.

Obituary.—We regret to record the death of Mr. C. H. Orwin, son of the late James Orwin, M.D., which occurred on September 26th, at Barbadoes, while returning home invalided. Mr. Orwin, who was born in 1853, served for five years with the Telegraph Construction and Maintenance Company, and in 1875 joined the West India and Panama Telegraph Company as electrician. In this capacity he took part in a great many cable repairs in the West Indies. When the "Grappler" was built for the West India Company he was appointed electrician on board, in which position he remained until his death. Mr. Orwin leaves a wife and family.

Portsmouth.—At a meeting of the Electric Lighting Committee of the Portsmouth Town Council, held at the Town Hall, it was decided that the appointment of Mr. J. N. Shoolbred, C.E., as consulting engineer for the installation, be deferred, in order that further opinion may be obtained, more particularly as to the financial aspect of the scheme and the revenue to be derived from the supply, which is to consist of 5,000 16 c.p. incandescent lamps and 100 arc lights. The committee unanimously resolved to invite Prof. Garnett, Principal of Durham College of Technical Education, to give his opinion on the matter, and until this is received no further action will be taken.

Personal.—On Saturday evening last Mr. G. F. L. Preston, late district engineer, and Mr. R. A. Dalzell, local manager of the National Telephone Company, at Sunderland, were presented with testimonials on their appointments to other districts. Some 60 members of the staff were present, and the proceedings were opened by Mr. Clay, who presented each gentleman with a handsome keyless gold watch on behalf of the subscribers. Messrs. Dalzell and Preston having replied, some vocal and instrumental music brought the proceedings to a close.—We learn from Mr. C. E. L. Brown, late of the Maschinen Fabrik, Oerlikon, that he is practising as a consulting engineer at Baden (Switzerland), under the style of Brown, Boveri and Co.

Birmingham Town Hall.—The electric lighting of this Hall has been carried out for the City Council under the superintendence of the firm of Henry Lea and Thornbery. The supply is obtained from the public mains of the Birmingham Electric Supply Company. The main body of the Hall is lighted by 18 pendants, carrying in all 200 32 c.p. obscured lamps without shades. There are in addition 23 16 c.p. lamps under the galleries, and 160 16 c.p. lamps in the corridors, &c. The roof also is lighted by 11 32 c.p. lamps. Double-pole main and local fuses are used throughout, having not more than six lamps on each local fuse. Throughout the recent musical festival the coolness and freshness of the building were remarkable both morning and evening.

Walsall.—At the meeting of the Town Council, on Monday, the General Purposes Committee reported that they had appointed Mr. F. Brown, of the Walsall Electrical Company, to advise as to the terms and conditions upon which the South Staffordshire Tramways Company shall be allowed to erect their overhead wires and work their tramways within the borough by means of electricity, and to superintend the carrying out of the works so as to ensure proper precautions for the safety of the public; and they recommend that the company be allowed to use steam twelve months longer on their lines within the borough, with a view to enable them to equip their lines for electric traction before the expiration of that period. The report and recommendation were adopted.

Electric Annealing of Steel Wire.—The electric current has been utilised since 1889 at the small arms factory at Saint-Etienne for annealing the steel wire of which the hammers springs of the rifle, 1886 pattern, are made. These springs are manufactured of steel wire, 7 millimetres thick, cut in lengths of 3·20 metres; the wire is rolled spirally, and a current of 23 amperes is passed through it. Heating is rapidly effected; when it is judged sufficient, the circuit is closed, and the hammer-spring is dropped into a water-tank. One man can anneal 20 springs in three minutes, equivalent to about 2,400 per day. Electric annealing being clean in operation, and cheap, will no doubt soon be applied in numerous cases analogous to the one indicated.

An Alumino-titanium Alloy.—The Pittsburg Reduction Company, of Pittsburg, Pa., is, says the *Engineering and Mining Journal* of New York, manufacturing a new aluminium alloy which promises to be of considerable industrial importance. It is an alloy of aluminium and titanium, discovered and patented by Prof. J. W. Langley, which possesses a remarkable degree of hardness—not so much in the cast form as when the metal is rolled or otherwise worked. Tools can be made of this alloy with a cutting edge which will hold nearly as well as steel. At the same time the metal has a resilience and spring which will make it of very considerable use for many purposes. The specific gravity of the new alloy is not much greater than that of pure aluminium. The amount of titanium used is very small. Indeed, when the proportion of this element exceeds 10 per cent., the alloy is too brittle for ordinary uses.

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Kelvinside Electricity Company.—A conference was lately held between a deputation from the Kelvinside Electricity Company and the Glasgow Corporation Committee on Electric Lighting. The deputation made the request that the Corporation, in order to maintain the control of the streets in their own hands, should lay down the electric mains required for the supply of electricity within the Company's statutory area, which is to be added to the city on November 1st next; and they stated that the Company would be prepared to pay a fair return on the cost of such mains in respect of the use thereof. Some conversation took place on the subject, and the Electric Lighting Committee assured the deputation that their request would be carefully considered. The deputation consisted of Messrs. J. B. Fleming (chairman), Finlay, and Paterson, with Mr. J. M. M. Munro, their engineer, and Mr. Alexander, the Company's secretary.

Cost of Street Lighting.—At a meeting of the Grays Local Board last week it was reported that in order to ascertain the conditions under which similar neighbouring towns were lighted, the Clerk had communicated with their authorities, and from the replies it was found that (with the exception of Southend) the lamps are lighted from sunset to sunrise on the following terms:—1st. Gravesend, £2. 5s. 6d. per lamp, the Corporation lighting, extinguishing, and cleaning; 2nd. Northfleet, £3. 3s. 6d. per lamp, the Gas Company lighting, extinguishing, and cleaning; 3rd. Romford, a portion of the lamps are lighted for ten months all night (except seven nights at each full moon, for which £3. 6s. per lamp is paid, the Company lighting, extinguishing, cleaning, and repairing. The other portions are alight all night all the year round at £4 per lamp; 4th. Southend, £2. 0s. 6d. per lamp; the lamps being extinguished at 11 p.m. from November to June, and at 11:30 from July to October.

City and Guilds Central Institution.—Of the candidates, some 100 in number, who presented themselves for the recent Matriculation Examination at the City and Guilds Central Institution, 64 passed, and 14 did sufficiently well to be admitted as unmatriculated students. In addition to the students who have come forward from last session, and these 78, all now attending courses in each of the four main departments of the College, some 14 special students have entered for advanced courses, and 59 for the courses on Carpentry given to elementary teachers. The departments of Mechanical and Electrical Engineering have now their full number of students. At this entrance examination the Clothworkers' Scholarship, of £60 a year and free education for two years, was gained by J. R. Dick, B.Sc., Edinburgh University; the Siemens Memorial Scholarship, of £50 a year for three years, by F. Maeers, St. Dunstan's College, Catford; the Mitchell Scholarship, of £30 a year and free education for two years, by E. L. Joselin, from the Finsbury Technical College; and the three Institute's Scholarships, giving free education for three years, were awarded to S. Mendel, Charterhouse School, R. J. C. Woods (educated abroad), and W. H. Everett, Queen's College, Belfast. At the close of the last session, the John Samuel Scholarship, of £30 and free education, granted to the best second year's student and tenable for his third year, was gained by F. H. Hummel, and the Siemens Medal for the student of greatest proficiency in the department of Electrical Engineering, by G. C. Turner.

Gutta-Percha in Singapore.—The *Kew Bulletin* for the current month reproduces from the *Comptes Rendus* an interesting article on the rediscovery of the gutta-percha tree in Singapore. Its existence there was first made known to the civilised world by Dr. Montgomerie in 1842, and the first specimens reaching Europe under that name arrived in London in April, 1843. Wheatstone conceived the idea of employing the substance in submarine telegraphy, and in 1849 a cable sheathed part of its length with gutta-percha was laid in the English Channel. It is becoming scarcer and dearer every year, and attempts have been made to replace it by some other substance in cables. Submarine telegraphy requires the finest gums, and the only ones which are of use as insulators are those produced by trees of the genus Isonandra (gutta-percha having been originally described as Isonandra Gutta), whose natural habitat is exclusively in the Malayan region. The destruction of the Malay forests proceeds rapidly owing to native waste; the gums are growing scarcer, and submarine telegraphy "is on the eve of finding itself destitute of those plants which are indispensable to it in the present state of science." The gutta-percha tree has been described as extinct in Singapore since 1857, but M. Sérullas in the ravines of an ancient forest in the island found the tree living and reproducing itself in 1887 at a place where all gutta collecting had ceased for 30 years. "The extinction of the tree was supposed to be complete. Nevertheless, hardly three years ago there still existed in the remnants of the ancient forest of the island adult trees of this species, represented chiefly by offshoots." As to the derivation of the word M. Sérullas remarks that "gutta" in Malay is only used in the general sense of gum or glue. The word "percha" does not mean Sumatra, as has been generally supposed. Sumatra is called by the Malays "perxa," which means the inhabited terrestrial world. Percha means "rag," and exactly characterises the appearance of the gums, which before treatment with warm water resemble rags half reduced to compressed paper-pulp. The *Bulletin* also contains an interesting section describing a new process for recovering the gutta-percha which is left in the bark of the trees after collection by the ordinary wasteful native methods. Some official correspondence on the subject has been published through the Colonial Office; and in a letter from the India-rubber, Gutta-percha and Telegraph Works Company, enclosing a report from Mr. T. T. P. Bruce Warren, it is stated that this sample of bark contained too much resin to make it of commercial value, the resin makes it brittle, and extraction by solvents would not be remunerative.

The Chicago Exhibition and the Chambers of Commerce.—We have no space to give the reasons why various towns think that it is worth while to exhibit at Chicago, but we make an exception in the case of the powerful arguments used at Bristol. The following opinions have been expressed elsewhere:—*Bradford.*—The question of Bradford participating in this Exhibition came up at the September Council meeting of the Bradford Chamber of Commerce on a letter from the Society of Arts. Sir Henry Mitchell said there was a pretty general feeling in the Bradford district that exhibitions of the kind named were becoming too frequent. *Bristol.*—The president reported at a meeting of the Council of the Bristol Chamber of Commerce on September 23rd that he had replied to Sir H. Trueman Wood, respecting participating in the Chicago Exhibition, to the effect that, as the birthplace of Sebastian Cabot, and as the point of departure of some of the earliest New England settlers, Bristol was very largely associated with the new world, and in view of the old association the Chamber had already appointed a sub-committee to consider what steps should be taken to bring the aim and scope of the Exhibition under the notice of local manufacturers. *Cardiff.*—The Chairman of the Council of the Cardiff Chamber of Commerce said he did not know what steps the Chamber could take in this matter beyond making the contents of the letter public. This was not an exhibiting district. It was then agreed to allow the letter to lie on the table. *Macclesfield.*—On consideration of the letter from the Society of Arts, Mr. J. O. Nicholson said that after America had put a duty of 60 per cent. on silk goods imported into their country, he would not spend a penny in sending out articles to be exhibited there. *Oldham.*—The letter was read at the meeting of the Oldham Chamber of Commerce, but no action was taken. *France.*—The Minister of Commerce recently sent a circular letter to the French Chambers of Commerce asking them to furnish him with a list of firms desirous of taking part in the Chicago Exhibition. The replies which have come to hand show that there is very little enthusiasm for the Chicago Exhibition, manufacturers being held back by the McKinley Tariff. The Chambers of Commerce of Bordeaux, Lille, and Roubaix inform the Minister that no intending exhibitor has yet communicated with them. The Chambers of Commerce of Lyons, Saint Etienne, and Roanne have each received one application. Nearly all the other Chambers of Commerce merely note the absence of any applicant.

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ELECTROMAGNETIC THEORY.—XVII.

BY OLIVER HEAVISIDE.

(*Continued from page 574.*)

§ 90. It may have been observed that the equations employed by me in the preceding differ from those in use in all mathematical treatises on the subject in a certain respect (amongst others), inasmuch as the constant 4π, which is usually so obtrusively prominent, has been conspicuous by its absence. This constant 4π was formerly supposed to be an essential part of all electric and magnetic theories. One of the earliest results to which a student of the mathematics of electricity was introduced in pre-Maxwellian days was Coulomb's law of the relation between the density of the electric layer on a conductor and the intensity of electric force just outside it, say

$$E = 4\pi\sigma; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

and, since this was proved by mathematics, it seemed that the 4π was an essential ratio between two physical quantities, viz., electricity and the force it exerted on other electricity. Never a hint was given that this 4π was purely conventional; it was not, indeed, even recognised to be conventional, and is not at the present day in some quarters. Then, again, at the beginning of magnetism, was Gauss's celebrated theorem proving mathematically that the total flux of magnetic force outward through a closed surface equalled precisely 4π times the total amount of magnetism enclosed within the surface; and, for all that might appear to the contrary, this remarkable result flowed out necessarily from the properties of the potential function and its derivatives, and of the three direction cosines of the normal to an element of the surface. It was funny—very funny. However the 4π managed to find its way in was the puzzle in these and similar results; for instance, in the well-known

$$\mu = 1 + 4\pi\kappa, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where μ is the permeability and κ another physical property, the susceptibility to magnetisation of a substance. The dark mystery was carefully covered up by the mathematics. It was as hard to understand as the monarch found it to explain the presence of the apple in the dumpling—how did the goodwife manage to get it in? Nor was the matter rendered plainer by Maxwell's great treatise. Maxwell thought his theory of electric displacement explained the meaning of the 4π (in the corresponding electric theorem), as if it were a matter of physics, instead, as is the fact, of irrationally chosen units.

As the present chapter has been mainly devoted to a general outline of electromagnetic theory expressed in formulæ involving rational units, it will be fitting, in bringing it to a conclusion, to explain here the relation these rational units bear to the ordinary irrational units.

§ 91. The origin of the 4π absurdity lay in the wisdom of our ancestors,—literally. The inverse square law being recognised, say that two charges q_1 and q_2 repelled one another with a force varying inversely as the square of the distance between them; thus,

$$F = aq_1q_2/r^2, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where a is a constant; what was more natural than to make the expression of the law as simple as possible by giving the constant a the value unity, if, indeed, it were thought of at all? Our ancestors could not see into the future,—that is to say, beyond their noses,—and perceive that this system would work out absurdly. They were sufficiently wise in their generation, and were not to blame.

But, after learning that certain physical quantities bear to one another invariable relations, we should, in forming a systematic representation of the same, endeavour to avoid the introduction of arbitrary and unnecessary constants. This valuable principle was recognised to a small extent by our ancestors, as above; it was emphasised by Maxwell and Jenkin in their little treatise on units in one of the Reports of the B. A. Committee on Electrical Standards (1863, Appendix C; p. 59 of Spon's Reprint). Thus, referring to the magnetic law of inverse squares, we have the following:—

"The strength of the pole is necessarily defined as proportional to the force it is capable of exerting on any other pole. Hence the force f exerted between two poles of the strengths m and m_1, must be proportional to the product mm_1. The force f is also found to be inversely proportional to the square of the distance, D, separating the poles, and to depend on no other quantity; hence, we have, *unless an absurd and useless coefficient be introduced*,

$$f = mm_1/D^2." \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Observe the words which I have italicised. When it is considered what Maxwell had then done in the way of framing a broad theory of electromagnetism, it is marvellous that he should have written in that way. By mere force of habit one might, indeed, not consider there to be anything anomalous about the 4π in Coulomb's and Gauss's theorems. But did not Maxwell's electrostatic energy $K\mathfrak{E}^2/8\pi$ and his magnetic energy $\mu\mathfrak{H}^2/8\pi$ per unit volume loudly proclaim that there was something radically wrong in the system to lead to such a mode of expression, which fault should be attended to and set right *ab initio*, especially in framing a permanent system of practical units, which was what Maxwell and his colleagues were about?

It would seem that the proclamation fell upon deaf ears, for not only were the units irrationally constructed, but in his Treatise, which followed some years later, we find the following statement (p. 155, second edition). After an account of his theory of electric displacement, we are told that "the theory completely accounts for the theorem of Art. 77, that the total induction through a closed surface is equal to the total quantity of electricity within the surface multiplied by 4π. For what we have called the induction through the surface is simply the electric displacement multiplied by 4π, and the total displacement outward is necessarily equal to the total charge within the surface." That is, his theory of electric displacement accounts for the 4π. So it seems to do; and yet the 4π has no essential connection with his theory, or with any one else's. Though by no means evident until it is pointed out, it is entirely a question of the proper choice of units, and is independent of all theories of electricity. It depends upon something much more fundamental.

§ 92. When looked into carefully, the question is simply this: What is the natural measure of the strength of a source? Suppose, for instance, we have a source of heat in a medium which does not absorb heat, how should we measure the intensity of the source? Plainly by the amount of heat emitted per second, passing out through any surface enclosing the source. If the flux of heat be isotropically regular, its density will vary inversely as the square of the distance from a point source, giving

$$C = S/4\pi r^2, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

if C be the heat flux (per unit area) at distance r from the source of strength S. If we knock out the 4π we shall obviously have an unnatural measure of the strength of the source.

Similarly, if we send water along a pipe and let it flow from its end, which may therefore be regarded as a source, we should naturally measure its strength in a similar manner, viz., by the current in the pipe, or by the *total* outflow.

Now in an electric field, or in a magnetic field, or in the field of any vector magnitude, we have everywhere mathematically analogous cases. We find, for instance, that electrostatic force is distributed like velocity in an incompressible liquid, except at certain places, where it is, by analogy, generated, or has its source. If, then, we observe that the flux of force through a closed surface is not zero, there must be sources within the region enclosed, and the natural measure of the total strength of the sources is the total flux of force itself. I have put this in terms of electric force rather than of electric displacement, merely to exemplify that the matter has no particular connexion with electric displacement. In the former case it is a source of "electric force" that is considered; in the latter, it would be of displacement; and the principle concerned in a rational reckoning of the strength of a source is the same in either case. It is a part of the fitness of things, and holds good in the abstract theory of the space-variation of vector magnitudes, apart from all physical application.

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Using, temporarily, the language of lines of force, or of tubes of force (which, however, as here, sometimes works out rather nonsensically), we may say that a *unit* pole sends out *one* line of force, or one tube, when rationally estimated.

Next there is the proper measure of the strength of circuital fluxes to be considered; electric current, for instance. The universal property here is that the circuitation of the magnetic force is proportional to the current through the circuit; and the natural measure of the strength of the current is the circuitation itself, without, as usual, dividing by 4π. Now this division by 4π arises out of the irrational reckoning of the strength of point sources. We may therefore expect that when the point sources are measured rationally, the 4π will disappear from the reckoning of electric current, making the circuitation of magnetic force the proper reckoning. This is so, as may be easily seen by substituting for a linear electric current an equivalent magnetic shell, and so bringing in point sources distributed over its two faces.

Thus, in rational units, if we have a point source q of displacement, and a point source m of induction, we have

$$D = q/4\pi r^2, \qquad B = m/4\pi r^2, \quad . \quad . \quad . \quad (6)$$

to express the displacement and induction at distance r, when the fluxes emanate isotropically; and

$$E = (q/c)/4\pi r^2, \qquad H = (m/\mu)/4\pi r^2, \quad . \quad (7)$$

if q/c and m/μ are the measures of the sources of electric and magnetic force respectively. In the magnetic case m may represent the strength of a pole, on the understanding that (since the induction is really circuital) we ignore the flux coming to the pole (as along a filamentary magnet), and consider only the diverging induction. Also,

$$H = C/2\pi r \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

expresses the intensity of magnetic force at distance r from a long solitary straight current of strength C.

§ 93. Considering merely the formulæ belonging to point sources with uniform divergence, we see that the effect of changing from irrational to rational units is to introduce 4π. If this were all, we might overlook the fundamental irrationality and use irrational units for practical convenience. But, as a matter of fact, it works out quite differently. For the unnatural suppression of the 4π in the formulæ of central force, where it has a right to be, drives it into the blood, there to multiply itself, and afterwards break out all over the body of electromagnetic theory. The few formulæ where 4π should be are principally scholastic formulæ and little used; the many formulæ where it is forced out are, on the contrary, useful formulæ of actual practice, and of the practice of theory. A practical theorist would knock them out merely from the trouble they give, let alone the desire to see things in their right places. Furthermore, it should be remarked that the irrationality of the formulæ is a great impediment in the way of a clear understanding of electromagnetic theory. The interpretation of equation (2) above, for instance, or of the similar well-known equation

$$\mathfrak{B} = \mathfrak{H} + 4\pi\mathfrak{I},$$

presents some difficulty even to a student of ability, unless he be given beforehand a hint or two to assist him. For if κ is a rational physical quantity, then μ cannot be; or if μ is right, then κ must be wrong. Or $\mathfrak{B}$, $\mathfrak{H}$, and $\mathfrak{I}$ must be incongruous. The 4π is also particularly inconvenient in descriptive matter relating to tubes of force or flux, and in everything connected with them.

This difficulty in the way of understanding the inner meaning of theory is still further increased by the 4π not entering into the magnetic formulæ in the same way as into the electric. Thus, it is $\mathfrak{D}$ and $\mathfrak{B}/4\pi$ which are analogues. Again, in many of the irrational formulæ the irrationality *appears* to disappear. For instance, in $\frac{1}{2}\Psi\rho$, in $\frac{1}{2}\mathfrak{A}\mathfrak{C}$, in $\frac{1}{2}\mathfrak{E}\mathfrak{D}$, in $\mathfrak{E}\mathfrak{C}$, and in some others. This is because both the factors are irrational, and the two irrationalities cancel. It looks as if $\mathfrak{D}$ were the flux belonging to $\mathfrak{E}$, but it is not. In reality, we have, if $x = (4\pi)^{\frac{1}{2}}$,

$$\mathfrak{E} = x\mathbf{E}, \qquad c\mathfrak{E} = x\mathbf{D}, \qquad \mathfrak{D} = x^{-1}\mathbf{D};$$

therefore,

$$\mathbf{E}\mathbf{D} = \mathfrak{E}\mathfrak{D},$$

whilst c is the same in both irrational and rational units.

§ 94. The question now is, what is to be done? Are we modern pigmies, who by looking over the shoulders of the giants can see somewhat further than they did, to go on perpetrating and perpetuating their errors for ever and ever, and even legalising them? If they are to be enforced, it is to be hoped that it will not be made a penal offence not to use the legal and imperial units.

The "brain-wasting perversity" of the British nation in submitting year after year to be ruled by such a heterogeneous and incongruous collection of units as the yard, foot, inch, mile, knot, pound, ounce, pint, quart, gallon, acre, pole, horse-power, etc., etc., has been repeatedly lamented by would-be reformers, who would introduce the common-sense decimal system; and amongst them have been prominent electricians who hoped to insert the thin end of the wedge by means of the decimal subdivision of the electrical units, and their connection with the metre and gramme, and thus lead to the abolition of the present British system of weights and measures with its absurd and useless arbitrary connecting constants. But what a satire it is upon their labours that they should have fallen into the very pit they were professedly avoiding! The perverse British nation—practically the British engineers—have surely a right to expect that the electricians will first set their own house in order.

The ohm and the volt, etc., are now legalised, so that, as I am informed, it is too late to alter them. This is a *non seq.*, however, for the yard and the gallon are legalised; and if it is not too late to alter *them*, it cannot be too late to put the new-fangled ohm and its companions right. It is *never* too late to mend. No new physical laboratory determinations will be needed. The value of π has been calculated to hundreds of places of decimals; so that rational ohms, volts, etc., can be now fixed with the same degree of accuracy as the irrational ones, by any calculator.

When I first brought up this matter in *The Electrician* in 1882-3, explaining the origin of the 4π absurdity and its cure, I did not go further than to use rational units in explaining the theory of potentials, scalar and vector, and similar matters; then returning to irrational units in order to preserve harmony with the formulæ in Maxwell's treatise, and I did not think a change was practicable, on account of the B. A. Committee's work, and the general ignorance and want of interest in the subject. But much has happened since then. The spread of electrical knowledge has been immense, concurrent with the development of electrical industries, to say nothing of theoretical and experimental developments. I therefore now think the change is perfectly practicable. At any rate, some one must set the example, if the change is to occur. I have, therefore, in the preceding, wholly avoided the irrational units *ab initio*; and shall continue to use rational units in the remainder of this work.

So far as theoretical papers and treatises are concerned, there is no difficulty. Every treatise on Electricity should be done in rational formulæ, their connexion with the irrational (so long as they exist) being explained separately (in a chapter at the end of the book, for instance), along with the method of converting into volts, amperes, etc., the present practical units. At present you have to first settle whether to use the electrostatic or the electromagnetic units, and then introduce the appropriate powers of 10. If rational formulæ are used, then, in addition, you must first insert the constant 4π in certain places, so long as the irrational units last.

When, however, the real advantages of the rational system become widely recognized and thoroughly assimilated, then will come a demand for the rationalisation of the practical units. Even at present the poor practician is complaining that he cannot even pass from magnetomotive force to ampere turns without a "stupid" 4π coefficient getting in the way. That the practical electrical units should be reformed as a preliminary to the general reform of the British units requires no argument to maintain. That this reform is coming I have not the least doubt. Even the perversity of the British engineer has its limits.

(To be continued.)

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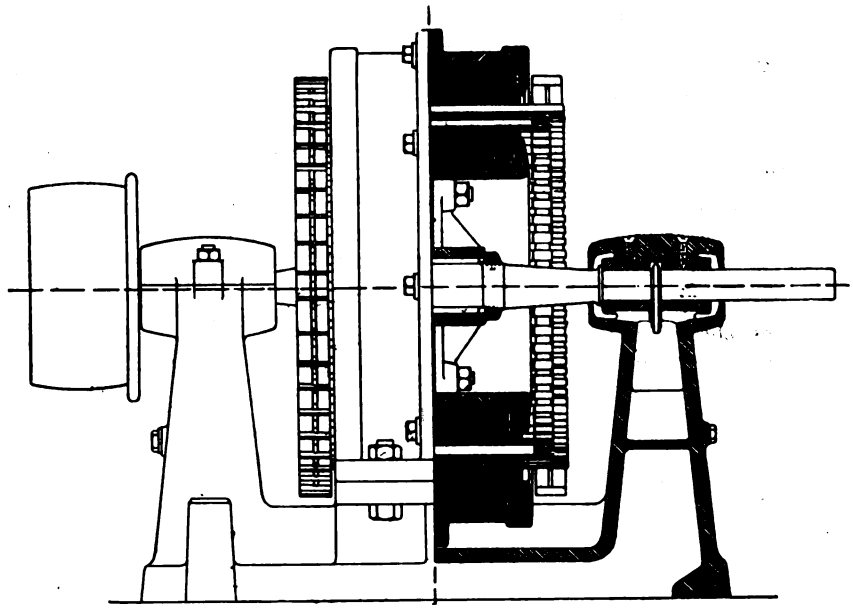
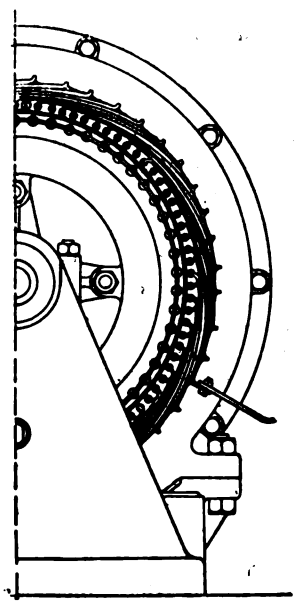
C. E. L. BROWN'S 20 H.P. THREE-PHASE ALTERNATE-CURRENT MOTOR.

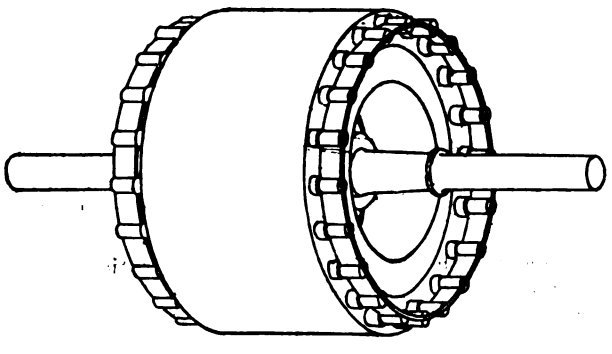
In the middle of last year Mr. Brown gave his attention to the use of multiphase currents, since the absence of sliding contacts in multiphase machinery is sometimes of considerable convenience, and may in the future be of great importance in the industrial use of electric motors. The Allgemeine Electricitäts Gesellschaft in Berlin were working in this direction, and the Oerlikon Company eventually joined with them to develop this system. In August, 1890, the first multiphase motor on a commercial scale was built to Mr. Brown's design. This machine developed 2 H.P., and has a perforated or "hole armature;" that is to say, an armature in which solid bars of copper are completely imbedded in holes in the iron core, the connections being made in Gramme fashion. In the same month Mr. Brown applied this perforated armature in connection with drum-winding to the 300 H.P. generator and motor designed for the electric transmission of power between Bülach and Oerlikon, which, though it is not generally known, suggested the Frankfort-Lauffen experiment; one of these machines, being, in fact, employed at Lauffen. The perforated armature in this application offers, among other advantages, the possibility of reducing the magnetising current to a minimum.



Elevation, half-sectional of Brown's Alternate-current Motor.



Half Elevation.



Armature of Brown's Alternate-current Motor.

From the illustrations it will be seen that the part which may be called the armature is stationary, and that the general arrangement is similar to the 300 H.P. generator. The armature being of a smaller size, it is provided with more than three wires per pole.

The three armature circuits are connected as in a Thomson-Houston armature, and the winding is so arranged that four rotating poles are produced (Fig. 3). With 40 cycles the motor makes about 1,200 revolutions per minute. The motor takes 30 volts normally; a reduction to 50, or an increase to over 100, will not make any practical difference in the speed. Of course, in the first case, the heating of the armature wire is greater, and in the second the heating of the iron is increased. The magnetic field rotates, and is produced by the armature reaction, thus avoiding all sliding contacts. The field-magnet is composed of a laminated ring with holes, in which are placed insulated copper bars. The free ends on both sides are connected by copper rings. It is not easy to imagine a more simple construction. Before giving results of the trials, some general data of the motor may be of interest. The armature has 90 conductors of about 40 sq. mm. section. The weight

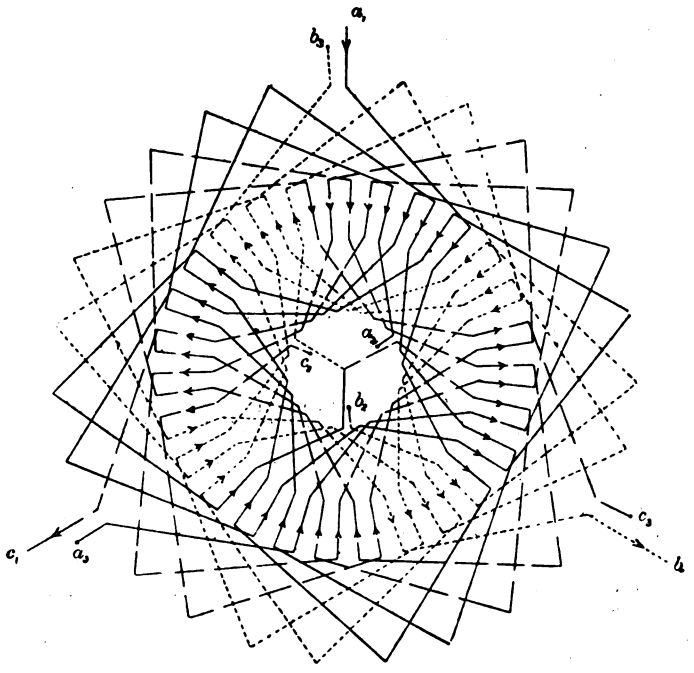


FIG. 3.

of copper is 20kg., the iron about 100kg. The breadth of the armature is 200mm., the outer diameter about 500. The rotating magnet carries 54 copper bars, with a section of 100 sq. mm. The weight of the copper is 15kg., that of the iron is 70. Recent trials in Oerlikon with this motor showed that it can easily supply 20 H.P. No part of the motor showed with a continuous run a higher temperature than 20°C. to 25°C. above the temperature of the test room. It may be of interest to mention

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that the rotating part shows practically no heating. The difference of speed between no load and full load is only about 3 per cent. The torque of the motor at starting is considerable. It easily ran a separately excited dynamo, which was working on a resistance absorbing 20 H.P. Over 200kg. torque could be obtained on the 20cm. pulley. The motor can carry also a considerable overload, and runs without the least noise. The starting of the motor is similar to that of a continuous current motor controlled by a resistance in series with the armature circuit. Regarding the commercial efficiency no accurate tests have been carried out. The losses in armature copper amount to about 4 per cent. in the magnet copper and iron, inclusive of friction, to 4 per cent. From this there would be an efficiency of 92 per cent. A commercial efficiency of 90 per cent. may be relied upon. That the losses are very small is further clearly shown by the very moderate heating, in spite of the small size of the motor and the absence of ventilation. A further advantage is that the commercial efficiency remains high, even if it works on a light load. The weight of the motor is 420kg., say a trifle over 20kg. per horse-power. For locomotive purposes it might without difficulty be reduced to 300kg., the result of which would be only 15kg. per horse-power. This result must be looked at as a very good one, especially considering the low current density with which the motor is worked. The bearings are automatically oiled, and contain large oil reservoirs, so that this motor should run without any attention for months.

IMPRESSIONS OF FRANKFORT EXHIBITION.

BY H. W. RAVENSHAW.

The German practice in dynamo building being so entirely different from ours, the following impressions may be of interest to those who have not been to the Frankfort Exhibition.

Taking continuous-current machines first, the immense size of the commutators and great number of sections are most striking, there being several commutators of at least three to four feet in diameter and having about 400 sections, the brush surface being about six inches long. These appear to be well designed and fitted up, but must be enormously expensive both in first cost and renewals. A far more simple arrangement is the use of the armature bars themselves as commutator sections, the 600,000 watt machine by Siemens and Halske being a magnificent example of this type of machine. The same firm also shows some alternating and continuous-current transformers with the secondary similarly built. The insulation between the sections is fibre. There was not the sign of a spark on any of these commutators, although being Exhibition dynamos it is not likely they were loaded. Siemens and Halske also show a number of over-type, continuous-current, wire-wound, drum-armature machines with wrought-iron commutators.

The commutators are open-ended and have air insulation between the sections, and appear to run very well. The armature ends are covered with black macintosh, which is tied round at the waist without any regard to true running, giving the machines when running a most slovenly look. In almost all the commutators in the Exhibition the wires from the armature are fixed by means of screws.

As regards general design, the saying that "whatever end up a dynamo is made, it can be made efficient even if it is inside out," is most remarkably exemplified, there being huge armatures with very small magnets inside, running close to large box-shaped magnets, the only evidence of whose armature is a commutator sticking out of a hole in the side. In fact, a Thomson-Houston machine strikes one as being quite neat and primitive by the side of some of the wonderful multipolars with a huge net-work of brush-holders sprawling over them.

It is curious to note that the bar-drum armature which is getting almost universal in England is entirely absent at Frankfort, the writer being unable to find one in the whole Exhibition.

The neatest machine on view is certainly one by Shuckert coupled to an engine by Kuhn, a disc armature with multipole side magnets, and a large commutator. It is beautifully finished and a grand job.* Close by is a gas engine coupled to a dynamo of the Manchester type, giving 7,500 watts at 200 revolutions, an immense plant for the output.

In alternating dynamos the use of iron in the armatures appears to be universal. Siemens and Halske and Helios Co. both have very large slow-speed machines of the Lontin type, the noise from which is tremendous, a loud trumpeting, evidently due to too great density in the armatures. But this could easily be obviated. A density of more than 10,000 per square cm. is sure to produce a humming noise in either dynamo or transformer.

Shuckert shows a multiphase alternator driving a similar motor, dynamos and motor separately excited, apparently starting together synchronously. This set is driving a rotary pump, which gives the motor a good chance to start without load. The Lauffen-Frankfort transmission plant is, of course, the most interesting exhibit, but the writer did not see the generating plant.

The Frankfort end however, is very interesting, the wires appear to be run in rather a primitive fashion, more particularly in the Exhibition grounds, where great numbers of bare wires are run, crossing each other in all directions, in very close proximity.

The motor strikes one as being of reasonable size and of compact design; the four brushes and collectors, however, are disappointing; the most fascinating feature of the rotary field transmission being the possibility of a motor with a rotary part entirely boxed in, and the entire absence of collectors or brushes. There is a very considerable amount of vibration of the revolving part, occurring about 20 times a minute; it would be interesting so know whether this is due to want of balance, or whether it represents the difference of speed of rotation between the rotary fields, and the revolutions of the machine.

The machine appears to be very strongly constructed, but the vibration is quite sufficient to cause considerable damage in time. The motor starts very smoothly with a splendidly rich hum, which however dies away as it gets up its speed. The machine is driving a rotary pump, the water from which does not appear till some time after the machine has attained its full speed.

The transformers are very large and leave a great deal to the imagination, as they simply look like big oil tanks. They are carefully locked up in a fireproof room. Some very fine engines are shown, those by Kuhn being capital examples of the marine type, the running exceedingly smooth, and the finish far superior to the average English engine. As to workmanship and material, it is not possible to judge by a casual inspection. A number of small open engines are shown, running at an excessively high speed. The running is smooth, but they must require very careful attention to keep in good order.

THE FRANKFORT EXHIBITION.—XIII.

(FROM OUR SPECIAL CORRESPONDENT.)

The firm of Siemens and Halske are well to the front with dynamos and motors with rotating magnetic fields. The small model motor, of which an illustration is given, together with diagrams of the method of winding, is a promising step in the direction of obtaining a rotary current motor in which the speed can be kept constant with varying load.

The motor differs from the usual three-phase motor in the fact that the "rotary" current is communicated both to the ring magnet and also to the armature. On the laminated iron core of the magnet ring are wound the three coils whose terminals are at *a*, *b*, *c*, Figs. 1, 2, 3. The other terminals of these coils are connected each with one of three brushes, their points of contact with the armature commutator being at equal intervals from one another. The armature is wound in the ordinary Gramme ring way, and the brushes are movable either to the left or right on the commutator, but always kept at the same distance apart by the vulcanite disc, on to which their supports are fastened. The currents to drive the motor are

* *See* full-page illustration, *The Electrician*, October 9th, p. 633.—ED. *E.*

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generated by a three-phaser, which is also provided with a commutator to allow of its being driven by continuous current; the three alternating currents of 120deg. phase difference being taken off three rings set on the axis beyond the commutator.

The currents thus given to the magnet wires, and through them to the armature, as shown in Figs. 1, 2, 3, create two rotating magnetic fields, one in the magnet ring, and the other

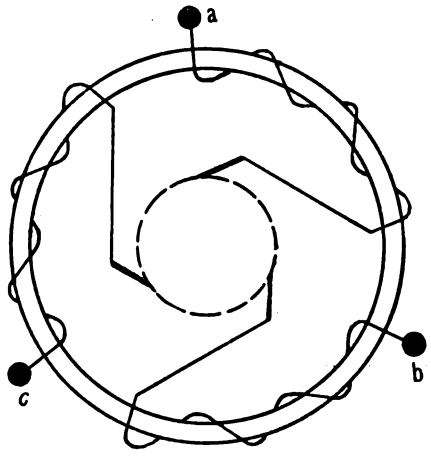


Fig. 1.—Magnetic Axes coincident. Motor stands.

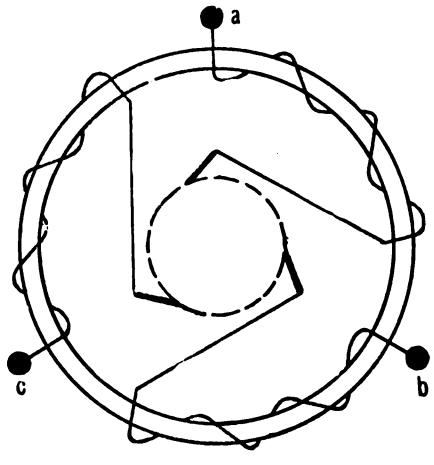


Fig. 2.—Left running. Brushes turned to left.

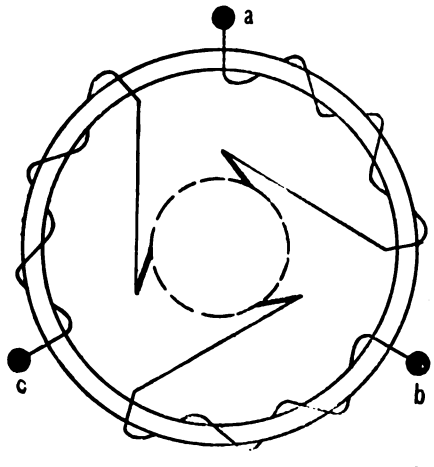
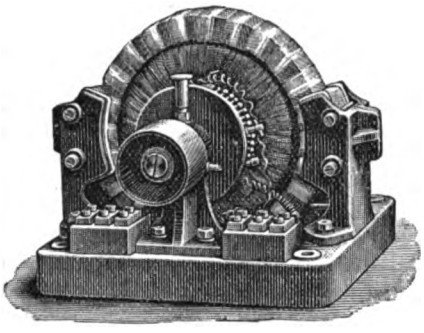


Fig. 3.—Right running. Brushes turned to right.

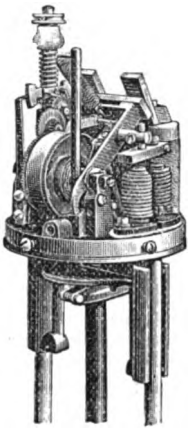
in the armature, the axes of the fields rotating with the same angular velocity. In Fig. 1, where each brush falls directly under the outer terminal of the coil with whose other terminal it is directly connected, the magnetic axes will be coincident in direction; and in Figs. 2 and 3, where the brushes are displaced to the left and right respectively, there will be certain angles between the axes.

In the first case, the repulsion between the poles of like name in armature and ring cannot result in turning the armature round, because it is, as it were, at a dead point, the poles of like name rotating one exactly over the other at the same rate.

If, however, as in Figs. 2, 3, the brushes are moved round in either direction, the magnetic axis of the armature field is moved backward or forward on that of the other field; and now the repulsion between the poles of the same name is able to force the armature round in the direction in which the brushes have been moved, the speed depending on the angle between the magnetic axes of the two fields, and, therefore, on the position of the brushes.



Siemens and Halske Three-phase Motor.

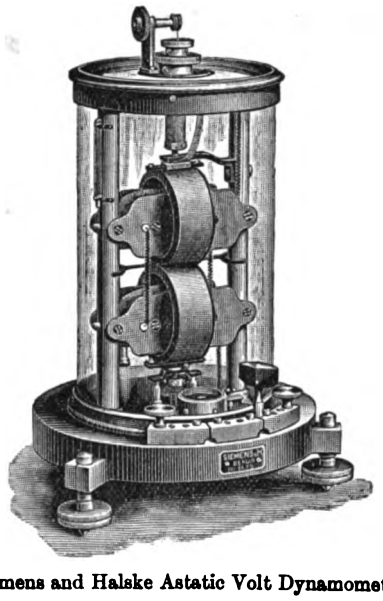


Siemens and Halske "Band" Arc Lamp.

The motor is only a small one, put together for experimental purposes.

The chief advantage of the system is the possibility of keeping the speed constant, or varying it from zero to the highest point in either direction by simply moving the brushes, an adaptability which would render it a useful motor if the rotary current ever came to be applied to tram driving, &c.

On the same stand as the above motor is another small rotary current motor without brushes made by the firm. It is for 1 horse-power, and of the same system as that already described in *The Electrician*. There are twelve coils wound in the Dobrowolsky method on the magnet ring, the winding method having, however, been designed independently. The armature which rotates inside the magnet ring is of solid



Siemens and Halske Astatic Volt Dynamometer.

iron with copper bolts running through it, and connecting the two flat copper discs which form the outer faces. The motor very quietly gets up to its highest speed (without load), and can by means of a switch be almost instantly stopped and reversed. The system has been described at such length in these columns that it is unnecessary to enter upon it here.

While dealing with Messrs. Siemens' exhibit we illustrate herewith the dynamometer and "band" arc lamp, of which a description will be found in our issue of last week.

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MULTIPHASE CURRENTS.

Fashion is essentially fantastic and inexplicable. "A volume on this subject," wrote the elder D'ISRAELI, "might be made very curious and entertaining, for our ancestors were not less vacillating and perhaps more capriciously grotesque . . . than the present generation." The latest fashion in electrical engineering is the Drehstrom. How are we to translate this expression? "Rotary current" is an ill-fitting name; for while we concede the time-honoured convention that an electric current has a direction, and for convenience of expression we say that it moves in such a direction, we are outstepping all licence of phrase when we talk of it as rotating. Nor do we mean to imply anything of the kind. The word "multiphase" has been suggested. True this is a hybrid, like bicycle, and we gave a trial some months ago to the more classically modelled "polyphase"; but if at least correctly compounded, it is too pedantic. With commendable boldness the fashionable dynamo and motor used for the Frankfort-Lauffen demonstration have been called "three-phasers," a hybrid expression indeed, but of some robustness. Three-phaser be it then till we are inflicted with more; but the word does not lend itself kindly to the derivatives, "three-phasing" and "three-phasedly."

With none of the candour of modern advertising, but with real sense of shortcoming, the purveyors of electric current of the alternating brand confessed some three years ago that it "won't run motors"; but everybody had an alternating motor in the dark, though the details could not of course be published "owing to incompletion of foreign patents." Then came the Tesla motor, very crude at first and very mysterious. It was thought, at all events, that something might be made

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of it. The efficiency was doubtful, and the torque on starting was a mere nothing; there were great variations in the strength of the magnetic field during each period, which gave rise to wasteful Foucault currents. Then, amid wonderfully tangled diagrams and strange formulæ, the Drehstrom was born, and we taught our tongue to form the name of DOLIVO VON DOBROWOLSKY. The man who, by adding another wick to an oil lamp, gave us the Duplex, made a very important invention; but when somebody else tried to add a third, it was held that he was only introducing unnecessary complications, and was offering no real advantage; but we are not going to compare three-phase currents with three-wick'd lamps. Under the comprehensive but not altogether pertinent title of "The Frankfort Exhibition" Mr. SWINBURNE has been writing several articles in *Industries* on this latest electrical fashion. There seems to be something very comprehensive about the Frankfort Exhibition; we notice that under the same title our contemporary *Nature* is describing the Deptford station. But to return to the last number of *Industries*, we find that the writer fails to see that the triple-current is any real advance upon the double-current machine. We really hope that he is right. There are many electrical engineers who will not be bothered with alternating currents of any description; they fortify themselves behind the excuse that this new-fangled system will not lend itself to storage or to transmission of power. The latter of these arguments has been knocked away by Mr. MORDEY, and long may they enjoy such security as is afforded by the other. Meanwhile, it is our duty to watch the new developments, to understand them if we can, and to keep our readers posted as to what is being done with them. We often long to hand the whole department of the alternate-current system to the charge of an assistant, and if the present complications increase he would probably want a multi-phase sub-editor to assist him.

Electrical engineering went on very well in the old days with continuous currents, when the Wheatstone bridge told us truly how many amperes would pass with a given number of volts, and we could wind magnets and use iron wire resistances with no misgivings or suspicion. Motors would mote without hesitation, aye, and rack their very keys with impetuous torque under the first rush of current. Nor were the Brush and Thomson-Houston folk afraid of high volts if generators for transmission to a distance were wanted. But an idea is prevalent that alternate currents lend themselves willingly to high pressure, the real facts being that on the one hand the armature coils of the dynamos are more easily kept apart, and that when the high-pressure current arrives at the end of the mains it can easily be transformed down to comfortable voltage. When Sir WILLIAM SIEMENS and Sir WILLIAM THOMSON spoke years ago of transmitting power from Niagara continuous currents were thought of, and with continuous currents the work might have been done.

But, taking the later development of the simple alternating current, what can it do, and what can it not do? Mr. MORDEY'S experiments afford the reply; and now that the scientific world is ringing with the Frankfort-Lauffen transmission we regret that these remain but experiments, conducted quietly with scarce a dozen witnesses, and no demonstration whatever. As though to meet a defect in his motors, the English inventor suggested that the continuous-current exciter coupled to the main shaft would run it up to speed from a battery, and when synchronism was attained the load could be put on. The glory of the three-phaser is that it will start. Some manipulation of resistances, it is true, is needed to check the rush of current at first, but it turns without necessarily synchronising with the generator. This facility of starting has easily been developed in the imagination of enthusiasts into a power of starting under full load; and the description in another column of the latest multiphaser by Mr. BROWN, one of the leading authorities on the subject, contemplates the use of such a motor for an application in which initial torque is of the utmost importance, viz., electric traction. The assumption by such an authority that a multiphaser will be suitable for this purpose is tantamount to a positive assertion, but it is to be noted that in all the descriptions which have hitherto appeared of the Frankfort experiment it has been assumed that the load, viz., that of pumping water, was taken up at once. Mr. RAVENSHAW informs us, however, in his brief article, which will be found elsewhere, that the water is not delivered until some time after starting, so the Frankfort demonstration cannot be said to show a starting under full load.

The writer to *Industries* says, in summing up, "We have given so much space to the discussion of the multiple current because so much has been said about it, and so much is expected from it. We have reluctantly come to the conclusion that it has no great future before it, and that it is not really the solution of the problem: and as this opinion seems to be opposed to that of nearly the whole electrical engineering world, we felt obliged to give reasons to support it." We think that the applause of enthusiasts has been mistaken for "the opinion of nearly the whole electrical engineering world." We admit all that the Lauffen-Frankfort transmission does, and are prepared to hear of more that can be done on this very interesting system. That the insulators were unable to stand the pressure of 30,000 volts need not be regarded as a failure. The chief points are the absence of sliding contacts and the stepping up and down of the volts, which is preferably done by alternate currents simply because it is easier to insulate a transformer than a dynamotor or ordinary motor. But the fear of the former is natural in Germany, where such prodigious commutators are to be found—commutators which do not spark it is true, for the non-sparking position is not a mere line, but a foot or so of the amazing circumference. The heavy "watt-less" currents, the difficulties of measuring, the complications and expense of the wiring, are serious objections to the wide development of multiphasers. If anybody wishes to transmit power for industrial purposes on the scale on which it is done at Frankfort, he has only to give an order for a reproduction of the admirable plant which is running so well. Cases in which such transmission will be remunerative are not likely to be very numerous, for it must be remembered that it does not lend itself to such bold schemes of general distribution as that recently propounded by Mr. MASSEY. A little more simplicity is desirable, and meanwhile we are inclined to look upon the whirling of the three-phase armature at Frankfort, in more senses than one, as a *tour de force*.

REVIEWS.

"Steam Boiler Construction." By WALTER S. HUTTON, Author of "The Works' Manager's Handbook," "The Practical Engineers' Handbook," &c. (London: Crosby, Lockwood, and Son.)

To electrical engineers engaged in the heavier branches of the industry the importance of a thorough knowledge and study of the various types of steam boilers, as well as a proper understanding of the management and working thereof, cannot be over estimated. For in a very marked degree does the efficient and economical supply of electrical power, when generated by steam, depend upon the manipulation and use of the boiler.

In the first place, the electrical engineer must be able to select from the various types of boilers placed before him by

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the mechanical engineer that boiler which is best suited to the purpose in view. This in itself may be said to be no easy matter, when it is remembered how many different points there are to be considered, each of its own importance and demanding due consideration. He is next called upon to be able to scheme and superintend the fixing and setting of the boiler, its flues, and chimney of suitable dimensions; the latter, again, is a matter of very considerable moment, as on it depends to a large extent the efficiency of the draught, which must be suited to the nature of the fuel to be used; while the arrangement of pipes for feeding the boiler and carrying away blow-off water, those for conveying steam to the engines, with all the accessories, such as pumps, injectors, valves, and cocks, necessary for the proper control of the station and which must be arranged in duplicate so that failure of one portion may not affect the continuous supply of steam, are such as to call forth quite an unlimited amount of ingenuity. Following the installation of the boiler is its proper management and use, which, perhaps, is most important of all, for on this not only depend largely the economical result as to the efficiency of the evaporation per lb. of coal, the fewness of repairs and the length of the life of the boiler, but upon it hangs the continuous supply of steam power which is necessary to maintain the continuity of the supply of current.

The steam boiler, then, is worthy of the greatest study and consideration of electrical engineers, and in the book before us we find a great deal of information of the kind required with the above object.

This work, which we should have thought more fitly entitled "Boiler Construction and Management," inasmuch as the latter absorbs quite half of the book, is divided into six sections, which we shall treat *seriatim*.

The first section commences with the subjects heat, radiation, and conduction, and contains useful tables of various properties of different substances; the various sorts of fuel are described, including liquid fuels. From this the author proceeds to explain the various methods of firing; but we do not agree with him that the so-called spread-firing system is necessarily the most efficient. Mr. L. E. Fletcher, in his exhaustive and well-known tests at Wigan, found that the coking system gave the best and most economical results. From mechanical stokers the author passes to the temperature and efficiency of the furnace, the composition of the gaseous products and smoke, and the effect of soot in depreciating the utility of the heating surface. We observe that in speaking of the temperature of the flue gases the author says that in well-arranged boilers the average temperature is 570°F.; we think, however, that this is somewhat high, as the weight of gases delivered by the chimney is only about 4 per cent. less at 350°F., a greater efficiency should be obtained by using the lower temperature and working at a lower rapidity.

In Section II. chimneys are first treated; as this subject does not receive the amount of attention in handbooks on engineering which it deserves, this part of the work is useful and interesting. With regard to the formulæ given for calculating the size of chimneys we should have preferred to have the constant C, which varies from ·1 to ·065, given in terms of the amount of fuel consumed, rather than in the number of boilers, which is somewhat vague. In speaking of the velocity of gases in the flues the friction against the sides of the flues does not appear to have been considered. It is customary to take this factor as being equivalent to a reduction in the size of the flue of two inches all round the perimeter, while Peclet found it varied as the hydraulic mean depth. From this we pass on to natural and forced draught; here some useful formulæ and data are given as to the comparative efficiency of the two systems. The composition of various sorts of feed water, and the effect of heat thereon, and the action of the water inside the boiler follow, while this section is closed by particulars of the evaporative results of different kinds of boilers, as well as the relative evaporative power per square foot of grate area. We observe that it is stated that an externally fired boiler will only evaporate 5lb. of water per lb. of fuel per hour; we fear that this statement will not be readily accepted in America, where, we understand, a large number of this class of boiler are now being manufactured and used. Table 38, as it stands, does not appear to us of much use, as it is obvious that with a temperature in the chimney of 1174°F., and other high temperatures, uneconomical results are obtained; but if the amount of evaporation per square foot of heating surface were added to this table it would be useful in showing the relation between economy and rapidity of evaporation per square foot of heating surface.

In Section III. are enumerated the requirements of a good boiler, which is well worthy of close reading. Then follow several pages on the heating surface of boilers, and the thermal conductivities of different metals. The evaporative power of the different sections of a boiler is well explained and illustrated by several tests, among which we note an average evaporation of 18lb. water per square foot of total heating surface per hour from 56° F., while with a so-called water evaporator 140lb. were evaporated per square foot of heating surface per hour. As the average working evaporation of stationary land boilers is 3lb. to 4lb. per square foot, it will be seen how much this quantity may be exceeded under favourable conditions. In passing, we may point out an error in the calculation of the average evaporation of the boiler referred to in page 125; this should be 12·4lbs. of water per square foot, and not 49·6, as stated. After devoting some space to smoke tubes, including various formulæ for the calculation of the strength and size thereof, the author returns again to the subject of heating surface. Water surface and the relative amounts of water and steam space are next treated of; and this part of the work, we think, is especially interesting to electrical engineers. A table is given showing the relative amount of water per square foot of heating surface contained in different types of boilers, from which a rough comparison of the amount of coal required to raise steam may quickly be made. Whilst speaking of this table we may remark that the quantities of water given for the Lancashire and Galloway boilers, viz., ·54 and ·47 cubic foot per square foot of heating surface respectively, seem somewhat low. We calculate for a Lancashire boiler 7ft. 6in. diameter, with 3ft. flues, ·9 cubic foot of water per square foot of heating surface, while the boiler sent by Messrs. Galloway to the Philadelphia Exhibition had ·6 cubic feet per square foot of heat surface. The quantity given for the water-tube boilers, such as Babcock's, viz., ·15 cubic foot, is about correct. The Lancashire boiler, then, contains six times the quantity of water to be heated up to evaporating temperature that is contained in a water-tube locomotive type of boiler, certainly a very strong argument in favour of the latter type of boilers when it is remembered that the coal used in steam raising in central stations must be averaged over but a few working hours. Details of grates and fire bars are next touched upon. We do not attach importance to the ratios between grate area and evaporative power of a boiler, as the former depends to so large an extent upon the nature of the fuel and conditions of draught. As it is always easy to reduce the area by firebricks laid on the bars, or otherwise, we prefer to have a large grate provided, unless the exact conditions are known beforehand. The author again returns to heating surface, afterwards treating the strains, stresses, and strengths of the shells and tubes of boilers.

Section IV. continues the subject commenced in the last section, and many interesting tests of the strength of various materials are given. The art of riveting is well explained, while boiler construction generally is treated in this section.

Section V. is chiefly descriptive of various types of boilers, and contains a number of illustrations, some of which are specially well drawn. We notice a number of different types of water-tube boilers. A table is given showing the comparative weights of various types of boilers.

Section VI. treats of boiler mountings, their size and strength; there are also rules and tables given as to steam pipes. We note that the author gives 5,100ft. per minute as the maximum rate of flow of steam in steam pipes permissible in practice, whereas Seaton gives 8,000. For central stations, owing to the length and multiplication of steam pipes, this question is one of considerable importance; by using large pipes we reduce the loss by friction, on the other hand we increase the loss by radiation, and *vice versâ*. Probably the best size lies somewhere between the two quantities above mentioned, but more reliable data on this subject is much needed. The author

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might have given more attention to methods for overcoming the difficulties of expansion in steam pipes, as in the use of high-pressure steam and long lengths of large pipes this matter is one of considerable difficulty, and has given rise to serious accidents in the past. Some useful hints are given as to prevention of scaling; and it should be noted that though there are many claimants to secret specific compounds effecting certain cures in all cases of scaling, there is no one compound which is applicable in all cases. The water must be treated according to the nature of the impurities contained therein, and that which is good for one may be bad for another sort of water. With an average water, a Lancashire boiler, evaporating 5,000lb. of water per hour, each gallon of water containing 28 grains of impurities, would have deposited per week of 54 hours about 1cwt. of solid matter; the greater part of this would be blown off in ordinary working. In a table giving the loss of fuel for different states of incrustation, we note that a scale of $\frac{1}{32}$in. thick causes a loss of 4 per cent., while $\frac{1}{4}$in. causes 38 per cent., and $\frac{3}{4}$in. 90 per cent. The tests given showing the saving obtained by use of an economiser, viz., 30 per cent., is perhaps misleading, as the heat of the chimney gases without the economiser was 645°F., showing that the boiler was either overworked, or that there was some defect in the heating surface, preventing the due transmission of heat from the flue gases. The information as to the inspection and testing of boilers is useful, and the notes on the heating surface necessary for the heating of various buildings by steam pipes is also of use. A number of actual cases of boiler explosions, with the causes thereof, are explained and illustrated; and the book closes with a paragraph on the life of steam boilers, in which we note that the author estimates the average life of a locomotive type of boiler at 10 years, and of a Lancashire boiler at 25 years.

The descriptions and formulæ are as a rule clear, and should be easy for all to understand, while the plates and illustrations are well done. At the same time, the book would be improved by some alteration in the arrangement of the subject matter. For example, the evaporative power of boilers is treated in Sections II., III., and VI., and in different parts of some of the sections, which necessitates turning to some half dozen parts of the book to learn all there is said on this one subject.

We commend this book to all interested in the practical use of boilers, as it contains a large amount of useful information carefully compiled.

MAGNETISM IN IRON AND OTHER METALS.*—LIII.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 603.*)

§ 183. **The Molecular Theory and the Effects of Temperature.**—To see the bearing of the molecular theory on experimental results regarding the effects of temperature on magnetic quality, we have to revert to Figs. 79, 80, and 81, § 111, which show Hopkinson's determination of the permeability of iron at various temperatures, for a small, a moderate, and a fairly strong magnetic force respectively. In the first of these figures (Fig. 79) the magnetic force is only 0·3, and consequently the susceptibility at ordinary temperature has the comparative small value which we expect to find in the first stage of the magnetising process. As the temperature is raised the susceptibility increases, at first but slightly, until a temperature of about 600°C. is passed. Then the rise in susceptibility becomes very rapid. It quickly increases more than ten-fold, showing that the effect of this heating is to *bring on the second stage of the magnetising process.* Finally, at a temperature of 775°C. or so there is an extraordinarily sudden fall of susceptibility, so sudden and complete that when the temperature reaches 785°C. practically all magnetic quality is lost.

Under a moderate force (of 4 C.-G.-S. units, *see* Fig. 80) there is none of the sudden rise of susceptiblity during heating which occurred when the force was weak. This is because, under the stronger magnetic force, the second stage in the magnetising process had already been entered before the piece was heated. Further, the loss of susceptibility at high temperature occurs much more gradually. Still more is this the case when the field is comparatively intense (Fig. 81).

The first effect of heating is to hasten the transition from the first to the second stage of the magnetising process, that is to say, to make this transition occur at lower value of the magnetic force. This is probably due to two causes. Heating expands the structure, and that weakens the ties between the molecules by increasing the distances between their centres. We may conjecture that it also sets up oscillations which contribute to make the ties more easily broken. When the field is weak, so that the second stage has not been reached while the metal is cold, heating is consequently favourable to magnetisation, and with an appropriate relationship of temperature to field the metal is in a critical state, in which a small rise of temperature produces an immense augmentation of susceptibility by making groups of molecules which were stable at the lower temperature become unstable at the higher.

This effect of heating cannot occur if the field is strong enough to have upset most of the molecules while the piece was still cold. Hence the curve of Fig. 80 has no sharp apex like that of Fig. 79.

The case of a fairly strong field is more simple. Heating has two antagonistic influences. On one hand, the alignment of the molecular magnets is still being facilitated by the weakening of their mutual forces. On the other hand, the oscillations which they acquire have virtually the effect of reducing the moment of each molecule. Throughout a wide range of temperature the two influences nearly counterbalance one another; the curve in Fig. 80 and Fig. 81 is nearly level for a great part of its course; but as the temperature becomes rather high the prejudicial effect becomes stronger,.and the curve bends down.

At this stage the molecules seem to acquire oscillation very rapidly, and a plausible conjecture to account for the complete loss of magnetic quality which ensues when the temperature rises a little higher, whether the field be weak or strong, is that the oscillation then becomes so violent as to develope into *rotation.*

The establishment of this rotation would account for the energy which we know to be absorbed during heating, while the iron passes from the magnetic to the non-magnetic state; and the rapid subsidence of this rotation into oscillations of comparatively narrow range, during cooling, would in the same way account for the energy which the iron then gives out as it recovers its power of being magnetised (§ 109).

§ 184. **Time-Lag in Magnetisation.**—The phenomena of magnetic viscosity, described in §§ 88 and 89, have some light thrown on them by the molecular theory. We saw that when a weak magnetic force is applied to soft iron, or is raised a step, the resulting change in the magnetism is not completed instantly. There is a protracted creeping up of the magnetism, which goes on long after the magnetic force has become constant. We saw that the softness of the iron and the thickness of the specimen had a great influence on the extent of the time-lagging. A piece of hard iron, or a very thin piece of soft iron, showed little or no lag; a thick piece of soft iron showed much, especially when the experiment was made at an early part of the second stage (stage B, Fig. 136) of the magnetising process.

§ 185. **Effects of Permanent Mechanical Strain.**—It was shown in § 66 that when a piece of iron is hardened by being strained sufficiently to take permanent set, the curve of I and H assumes a rounded form which allows the condition of the metal to be readily recognised. The successive stages of the magnetising process become much blended. No part of the curve has nearly so steep a gradient as we find in dealing with annealed iron. The susceptibility is less throughout, and saturation is approached with greater difficulty. There is much less retentiveness; on the other hand, there is much more coercive force. We may refer back, in illustration of these differences, to Fig. 34, § 66, where the curves for a cyclic pro-

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cess of reversal are drawn side by side for the same piece of iron in the annealed and hardened states.

These differences, regarded in connection with the molecular theory, seem to indicate that mechanical set resolves a structure which is relatively homogeneous and continuous into one which may be described as a patchwork of more or less distinct molecular groups. Hardening the metal by set makes only a slight change in the density, and it appears probable that it brings some of the molecules closer together, while the intervals between others are widened, with the result that groups are formed in which the intermolecular forces between members of any one group are stronger than the forces which are exerted across the wider gaps between members of different neighbouring groups. The "gaps" tend to shear over the curve of I and H, to round the outlines of the curve, and to reduce the residual magnetism. The closeness of the members within each group increases the coercive force. Thus, without any necessary change in the density of the metal, this modification of the structure would bring about the alteration in magnetic quality which is observed. Another consideration lends some support to this view. In hard metal there is exceedingly little, if any, "time-lag" in magnetisation. The explanation of "time-lag" suggested in the last paragraph seems to require that the structure (of annealed iron) be continuous throughout platoons of many molecules As soon as the platoons are split up into little groups the action described there cannot be expected to take place.

In connection with this it may be remarked that any interruption of the continuity of the molecular structure tends in some measure to shear over the diagram of I and H, and, in particular, to reduce residual magnetism, by making the conditions of constraint of molecules at and near the boundary differ from those of molecules far from the boundary. It seems probable that this consideration gives a clue to the "magnetic resistance" of joints, described above in §§ 162-165. Let the separated parts of a cut bar be ever so well fitted together, the molecules at the boundary, and for some little distance from it, are not subject to the same conditions of constraint as subsist in the uncut bar.

(To be continued.)

THE MEASUREMENT OF HYSTERESIS AND EDDY CURRENTS IN TRANSFORMERS.

BY SYDNEY EVERSHED AND ERNEST B. VIGNOLES.

The publication by Prof. Ewing, in *The Electrician* of October 9th, of the method of measuring loss by hysteresis and eddy currents in alternately magnetised iron, suggests to us that it may be of interest to record some results obtained, early in the present year, by a similar method to the one described. We say, "hysteresis and eddy currents," for it is clear that the latter source of waste cannot be neglected, even when the core consists of a bundle of iron wires.

The measurements were undertaken primarily with the view of trying whether an explanation of the effect which Mr. Mordey's experiments appeared to indicate—viz., decrease of the power wasted by hysteresis and eddy currents in the iron at full load—could be found in the fact that transverse magnetisation is applied to certain parts of the core when current is flowing in the secondary, which is not present when the secondary circuit is open. The transverse magnetisation is due to the construction of the transformer, in which the primary and secondary coils are wound side by side, thus producing local distortion in the main induction path.

From results previously obtained we had reason to suspect that such cross-magnetisation might result in a decrease of hysteresis; and although the disturbance in an ordinary transformer is extremely small and confined to a small portion of the core, it was conceivable that the effect might spread to the remainder of the core; just as in a super-saturated solution of some salt a small local disturbance instantly crystallises the whole mass.

The question we set ourselves to investigate, therefore, was: Does a transverse alternating magnetising force in a piece of iron affect the loss by hysteresis and eddy currents produced by an alternating longitudinal induction?

We determined to measure the loss by means of the rate of the rise of temperature in a model transformer, using a delicate clinical thermometer for the purpose. When the proper corrections are applied, the rate of rise of temperature is a measure of the rate of production of heat, and consequently of the waste of power in eddy currents and hysteresis.

A thermometer seems less likely to lead to errors than the use of a thermo-electric junction and galvanometer, from the circuit of which it would be difficult to eliminate induced currents. Of course, even the most sensitive thermometer lags behind the temperature, but as we are only concerned with the *rate* of production of heat a very small time lag cannot affect the results; and, as a matter of fact, we found the lag almost inappreciable.

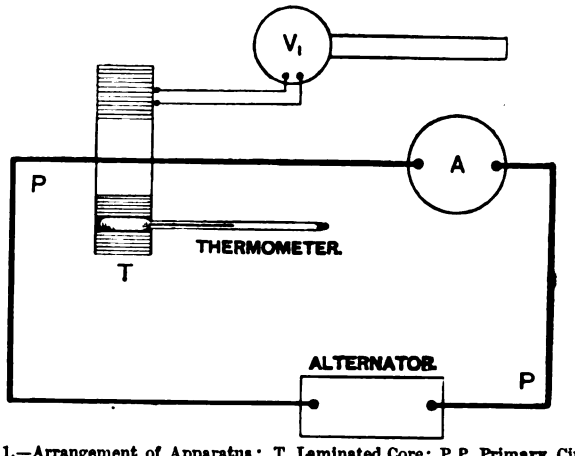

FIG. 1.—Arrangement of Apparatus: T, Laminated Core; P P, Primary Circuit; A, Ammeter; V_1, Cardew Voltmeter connected to Secondary Circuit on Core measuring Induction in Core.

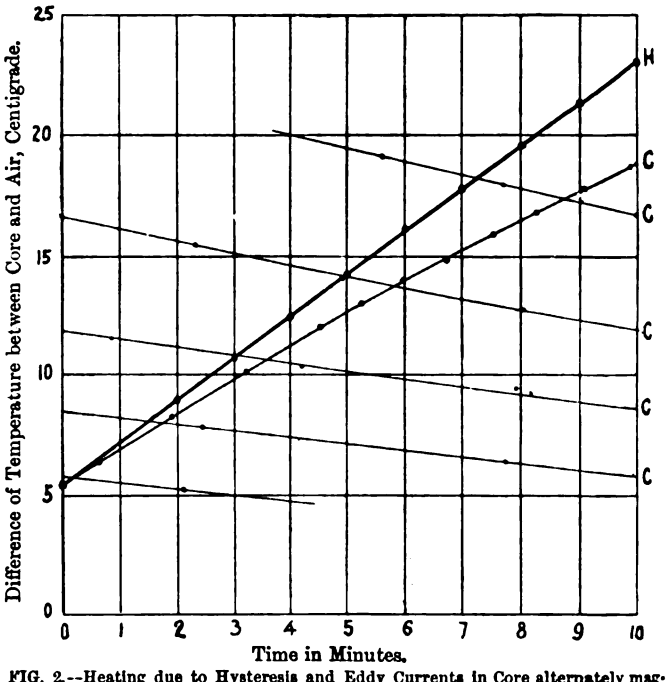

FIG. 2.—Heating due to Hysteresis and Eddy Currents in Core alternately magnetised longitudinally: O, Observed rise; H, Rise corrected for cooling; C C C, Cooling curve. Mean production of heat = 1·77° C. per minute.

We built a transformer of charcoal iron tape, each turn insulated from the last (the lamination being at right angles to the plane of the transformer), and bent so as to form a chamber in the interior of the core, into which the thermometer bulb tightly fitted. The transformer was wound evenly with a secondary coil of 105 turns of No. 24 wire, while the primary consisted of a single stout conductor, on which the transformer was threaded.

The induction in the core was measured by a Cardew voltmeter on the secondary circuit, allowance being made for the loss of volts due to the secondary winding. The primary current has only to be kept constant, and need not be accurately known, except so far as is necessary to reproduce its effective value in a direct current. The standard ammeter of Messrs. Goolden and Co.'s calibrating room was used for the purpose. The arrangement of the apparatus is shown in Fig. 1.

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In the first experiment we determined the rise of temperature in the core while the speed of the alternator, the primary current, and the secondary volts were kept constant. Having allowed a rise of 15°C. or 16°C., the alternating current is quickly replaced by its equivalent direct current, and a cooling curve is taken, from which the rate of cooling at any particular

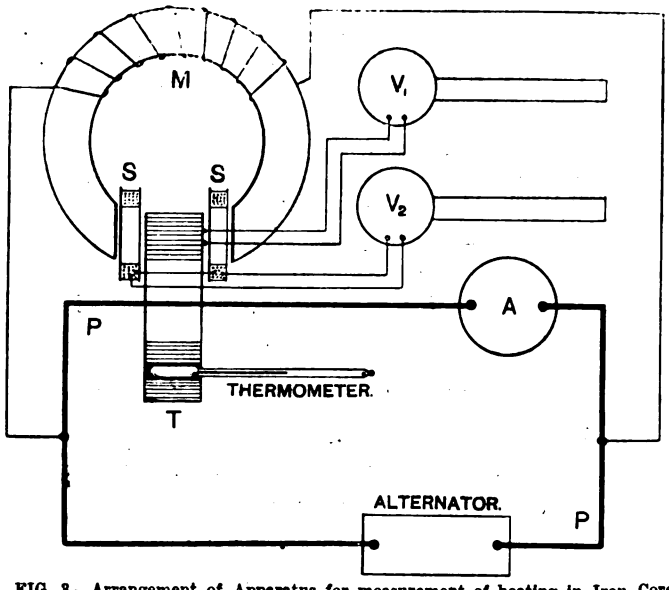

FIG. 3.—Arrangement of Apparatus for measurement of heating in Iron Core under alternating longitudinal and cross magnetising forces: T, Laminated Core; P P, Primary Circuit; A, Ammeter; V_1, Cardew Voltmeter measuring longitudinal induction in Core; V_2, Cardew Voltmeter attached to Coils S S measuring cross induction.

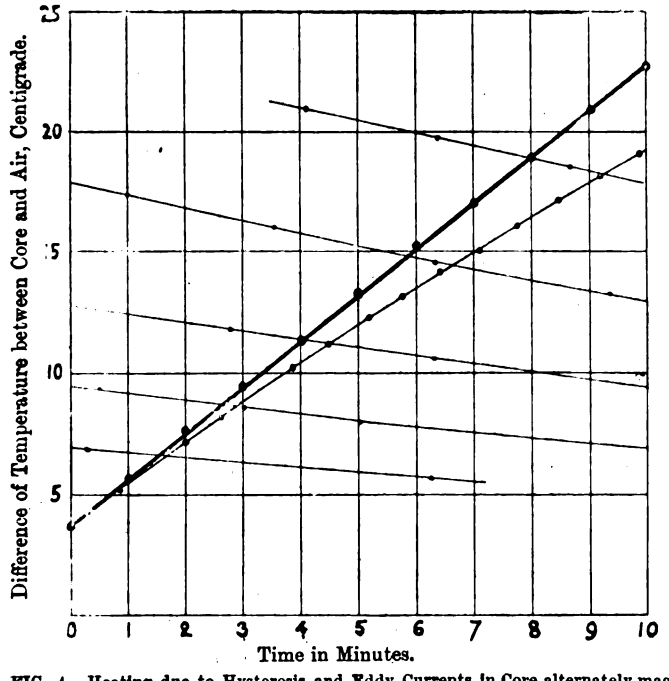

FIG. 4.—Heating due to Hysteresis and Eddy Currents in Core alternately magnetised longitudinally with transverse alternate magnetisation. Mean production of heat = 1·91° C. per minute.

temperature may be determined. It is clear that the only cause of difference between heating with the alternate and the direct current is the waste of energy in the core, provided the temperature of the surrounding air remains constant, or that any small variation is allowed for. It will be noticed that we neglected the heating effect of the voltmeter current, the resistance of the secondary being very small; it may obviously be corrected by maintaining the equivalent direct volts in the secondary circuit during the cooling.

The method of correction for cooling is as follows:—Taking any temperature as a starting point, note the rise in any small time "t." From the cooling curve get the rate of cooling at the mean temperature during this interval; and add to the observed rise the loss by cooling in the time "t," thus obtaining a point P on the curve denoting the rate of production of heat.

Taking this point as a new datum, the repetition of the process gives the next point; and so on. The slope of the resulting curve is the rate of production of heat. The uncorrected heating and cooling curves are so nearly straight that no error is introduced by taking the successive points at comparatively long intervals.

The rate of heating being uniform, the curve should be a straight line; and it is a remarkable and gratifying proof of the soundness of the method that the curves given in Figs. 2 and 4, are, within the limits of observational error, absolutely straight lines. The following are the results obtained:—

Experiment I.—*Observations: March 5, 1891.*

No transverse magnetising force.

Frequency = 104 ∽ Primary current = 125 amperes. Secondary volts = 27·5 Maximum induction density = 8,900 gausses.

No.	Time.	Temp. of iron.	Temp. of air.	No.	Time.	Temp. of iron.	Temp. of air.
	H. M. S.	C°.	C°.	Alternate current replaced by direct.			
1	3 20 37	21	14·7		H. M. S.	C°.	C°.
2	21 54	23	...	14	3 33 56	35·8	...
3	23 11	25	...	15	35 36	35	...
4	24 31	27	...	16	37 41	34	16·1
5	25 15	28	...	17	39 58	33	...
6	25 59	29	...	18	42 19	32	16·6
7	26 44	30	...	19	44 57	31	...
8	27 30	31	...	20	48 3	29·9	17·2
9	28 15	32	...	21	50 50	29	...
10	29 2	33	...	22	54 11	28	17·7
11	29 50	34	...	23	57 55	27	...
12	30 42	35	...	24	2 26	26	18·3
13	31 31	36	...	25	7 44	25	...
...	...	...	15·5	26	12 7	24	...
				27	18 29	23	18·8
				28	26 3	22	...

For the second experiment, a laminated magnet was arranged as shown in Fig. 3, so as to magnetise transversely a portion of the transformer core; the amount of transverse induction being measured by a coil embracing it and connected to a Cardew voltmeter. The magnet was excited by an alternate current, arranged in parallel with the primary circuit. This arrangement was adopted in order that the phase of the current in the magnet might be independent of that of the primary circuit; and by winding a suitable number of turns on the former the cross magnetising force is at its maximum when the primary current is about zero.

Experiment II.—*Observations: March 5, 1891.*

Transverse induction = 2,300 thoms. Frequency = 104 ∿ Primary current = 125 amperes. Secondary volts = 27·5. Maximum induction density = 8,900 gausses.

No.	Time.	Temp. of iron.	Temp. of air.	No.	Time.	Temp. of iron.	Temp. of air.
	H. M. S.	C°	C°	Alternate current replaced by direct.			
1	6 3 51	20	14·9		H. M. S.	C°	C°
2	5 0	22	...	15	17 7	36	...
3	5 38	23	...	16	19 21	35	...
4	6 52	25	...	17	21 39	34	...
5	7 29	26	..	18	24 0	33	16·0
6	8 45	28	...	19	26 32	32	...
7	9 24	29	...	20	29 20	31	...
8	10 5	30	...	21	32 19	30	16·6
9	10 45	31	...	22	35 46	29	...
10	11 27	32	...	23	39 19	28	...
11	12 10	33	...	24	43 30	27	17·7
12	12 51	34	...	25	48 1	26	...
13	13 38	35	...	26	53 18	25	...
14	14 23	36	15·2	27	59 15	24	18·3

It will be noticed from the curves (Figs. 2 and 4) that the rate of heating is nearly 8 per cent. greater in Experiment II. than in Experiment I. This proved that whatever the results obtained by Prof. Ayrton and Mr. Mordey might be due to, cross-magnetising force was not the cause.

Leaving this question for the time, we next compared the calculated loss by hysteresis and eddy currents with that obtained experimentally by the method described above; and the results of this investigation will form the subject of another article.

[A "thom" = 1 line of force, a "gauss" = 1 line per sq. cm.—Ed. *E.*]

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THE ELECTRIC LIGHTING OF DUBLIN.

At the annual conference of the Incorporated Association of Municipal and County Engineers, an interesting communication was given of the plant and arrangements for lighting the city of Dublin, by Mr. Spencer Harty, the city engineer. In accordance with powers obtained the Corporation of Dublin have now in course of construction a central electric lighting station to supply the first area covered by their licence. The streets through which the mains for public and private lighting will now be carried are as under :—Westmoreland-street, Sackville-street, Mary-street, Grafton-street, College-green, College-street, D'Olier-street, Henry-street, Dame-street, Parliament-street, Capel-street (part of), provision being made for future extension of the area as required. The public lighting will be by means of Brockie-Pell single carbon arc lamps in series, taking a current of 10 amperes and 50 volts, and arranged to burn 16 hours without re-trimming. They will be fixed on iron lamp-posts 21ft. high to centre of lamp, of ornamental design, and fitted with weather hoods and opalescent globes : in the base of each post will be fitted a special short-circuiting switch, to enable any lamp to be completely isolated from the circuit when necessary, and alternate lamps will be on different circuits to avoid the total extinction of light in case of temporary interruption to any one line of conductor. The current will be generated by Brush dynamos and will be kept constant by an automatic regulator. The supply for the private lighting will be on the "high-tension alternating-current transformer system," the pressure in the street mains being at 2,000 volts, and reduced by transformers in the consumers' houses to 50 or 100 volts as desired. The transformers are guaranteed to reproduce in the secondary circuit 95 per cent. of the energy absorbed in the primary circuit at full load, and not less than 75 per cent. at half load, and will run continuously without overheating. The generating plant is being erected upon land belonging to the Corporation, situated at the back of the Bank of Ireland, and will cover an area of about 12,000 square feet, with room for future extension. The frontage in Fleet-street is of red brick with granite string courses, and comprises a three-story building in which the various offices, stores, switch and test rooms will be placed, and a machinery hall 100ft. long, 50ft. wide, and 40ft. high, the latter being ventilated by swing windows in the sides and skylights in the roof. At the back of these buildings the boiler house, coal stores and water tanks are placed, and at one end a brick chimney 120ft. high from the ground level is being erected. The foundations for the walls of main buildings are of cement concrete, and are carried 12ft. below the ground level, the foundations for the engines, dynamos, and chimney being carried some 2ft. lower, to the solid rock. The engines selected for driving the private lighting plant are being built by Victor Coates and Co., of Belfast, and consist of three pairs of coupled compound non-condensing horizontal engines, guaranteed to realise 280 h.p. on the fly-wheel of each pair, with steam pressure of 140lb., and running at 85 revolutions per minute, the diameter of the high-pressure piston being 17in., the low-pressure 34in., and the length of stroke 36in. The public lighting plant will be driven by three vertical compound engines, each capable of realising 60 brake horse-power at a speed of 220 revolutions per minute with steam at 140lb., the high-pressure cylinder being 9in. diameter, the low-pressure 15in. diameter, and the stroke 10in.; the cylinders will be fitted with automatic and hand expansion gear, adjustable while the engine is running, and the governor will be of a specially sensitive high-speed type. The output of the plant installed is equal to 120 arc lamps of 50 volts each, and 5,000 incandescent lamps of 60 volts each, being in use at one time, with one complete spare plant in reserve in each case. The switch-room, situated on the ground floor of the office building, is separated from the engine-room by a glazed partition, and will contain three complete sets of Lowrie-Hall automatic regulating apparatus to maintain a constant electromotive force at the terminals of the alternators ; this is effected by placing a shunt of varying resistance across the field of the exciter.

The test-room, which is placed adjoining the switch-room, is fitted with a very complete set of instruments for testing the condition of the various circuits and machines, and recalibrating the numerous ammeters and voltmeters in use in the station ; the adjustment of meters and testing transformers will also be carried out here. The Thompson reflecting galvanometer is mounted on a concrete pillar, carried some 12ft. below the ground line to minimise vibration. The Wheatstone bridge and testing battery will be permanently connected on an isolated testing table in a convenient form. The boilers will be fed by three Worthington steam pumps, each one capable of supplying sufficient water to two of the boilers when fully loaded, and arranged so that any boiler can supply any pump with steam entirely independent of the main steam pipes. The Corporation will bring their surface lines, free of expense, to any consumer's premises, situated within 30ft. of any of their mains, any extra charge being made for any greater distance, and in all cases the consumer's installation must be passed by the Corporation Inspector before connection will be completed, and be in accordance with the rules laid down by them to secure efficiency and safety. The charge to the consumer will be either by special contract or by meter as may be desired, the minimum charge per quarter being £2 for any quantity up to 60 units ; for any quantity over 60 units and under 100 units per quarter, 8d. per unit ; for any quantity over 100 units per quarter, 6d. per unit. Hire of meter per quarter, 6s. Hire of transformer, primary safety fusible cut-outs :—For 25 16 candle-power lamps per quarter, 5s. ; for 50 do. per quarter, 10s, ; for 100 do. per quarter, £1 ; for 150 do. per quarter, £1. 10s. ; for 200 do. per quarter, £2. The meters will, of course, be fixed on the low-tension mains, their accuracy being guaranteed by the Board of Trade Inspectors, and the current will be available for twenty-three hours per diem. The entire cost of the works as at present designed will be about £31,000, and will be maintained by, and kept under the control of, the Corporation.

ELECTRIC MINING-MACHINERY, WITH SPECIAL REFERENCE TO THE APPLICATION OF ELECTRICITY TO COAL-CUTTING, PUMPING, AND ROCK-DRILLING.*

BY LLEWELYN B. ATKINSON AND CLAUDE W. ATKINSON, ASSOC. MM. INST. C.E.

(Continued from page 647.)

DISCUSSION *(continued).*

Mr. FRANK BRAIN said that with reference to the plant his firm had put down at the Trafalgar Colliery in the Forest of Dean, he might mention that they had increased it three times and had had no trouble with it. With the first installation they carefully boxed up the cables, anticipating that a fall of the roof might damage them. When they put in the second and third installation they did nothing of the kind, as it was found that there was no necessity for it with a fairly insulated cable, to which proper attention was given. It was a non-gaseous mine, and the trouble from the falling of the roof, &c., was very small. He had closely followed the discussion with reference to the means taken to prevent the explosion of gas. As a practical man he looked upon the machine as well fitted for putting into the hands of the miner. There were many mines where it could be used without danger from fire-damp, and he thought it was one of the most practical in the market. It was so strongly made, and so closely boxed up, that it appeared almost impossible to injure it. It was much better, as the authors had shown, to protect an armature going at a high speed, in a machine which was intended for use in a dark mine. That he regarded as a distinct advance, apart from the question of gas. The authors stated that the construction of the machine was such that they could ensure its running in explosive gas for two hours with perfect safety. If so, that was all that colliery managers required, and so far from suggesting that a non-explosive compound should be introduced, he would say, "Stick to your text and prove it, and we shall be satisfied." The matter of efficiency had exercised his mind. At the meeting of the South Wales Institute, the President, Mr. Colquhoun, who had a great deal to do with colliery plant, summed up ; he said he had had nothing to do with electric motors, but he must confess that, so far as his experience went, the efficieney of compressed air machinery had never exceeded 25 per cent. Mr. Brain had recently spoken on the subject to an eminent engineer, who was describing a large compressed air plant with all the latest improvements which he was putting down ; and on asking him what efficiency he expected, he said that he hoped to get 40 per cent. A short time since, a large colliery owner whom Mr. Brain knew asked his manager to furnish him with indicator diagrams of the compressed air plant at all his collieries, and the efficiency was found to be 17 per cent. In the case of some modern machinery belonging to one of his friends (who had nothing to do with electricity), the average result obtained from the diagrams was 18 per cent. That was pretty strong evidence as to the present day efficiency of compressed air plant.

Prof. GEORGE FORBES differed from the authors as to the danger of using the machinery which they suggested in fiery mines. He believed that in 1878 the largest employers of coal-cutting machinery in the country were the firm of Merry and Cunninghame. They were then using compressed air to drive it and were getting an efficiency of about 25 per cent. He was asked to look into the question of applying the electrical transmission of energy to the purpose. He accordingly worked out a plan, and was only deterred by a consultation with Mr. John Cunninghame, the manager of the Company, who with himself came to the conclusion that the danger of sparking was so serious that it was utterly impossible to employ electrical motors for coal-cutting machinery. And he still said, after carefully reading the authors' Paper, that even with the precautions therein mentioned, it would be dangerous to introduce the machinery described into a fiery mine. Various theoretical reasons had been given why it was perfectly safe. First, it was said that in the ordinary way of using an electric

* Abstract of discussion on the Paper read before the Institution of Civil Engineers.

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motor the temperature of the spark was so low that it would not fire an explosive mixture. The authors further said that, even if an explosion could be so caused, they had enclosed the commutator in a casing by which such a result was rendered impossible. They maintained that there never could be any serious accumulation of marsh-gas in the casing, because the spark of the commutator would be continually burning it up; in other words, that the sparking was really a safeguard against an explosion. He thought they had utterly failed to recognise the fact that if the machine were left for a considerable time the gases would accumulate inside the casings, which would be a very serious matter when the machine was started again. It was said in the Paper: "These precautions, which have been carried out successfully in practice, are, in the authors' opinion, amply sufficient to meet all objections on the point of safety in connection with the application of electric motors to mining work." He wanted to know what those words meant. Had the machine been tried in an explosive mine, where there was known to be an explosive mixture of gases at the place where it was used, or (what was much more important) had it been worked in a chamber filled purposely with an explosive mixture of fire-damp and air? He then described the Tesla motor, and he thought they were certainly the type of machine that would naturally be employed in places where there was danger from fire-damp.

Mr. JOHN TAYLOR referred to some gold mines in California, the property of a company of which his firm had the management. They had been abandoned for some years, in consequence of the impossibility of working them to a profit by steam-power, the ores being of low grade. A Pelton wheel, 87 inches in diameter, and capable of developing 125 H.P. with 400 miners' inches of water under a pressure of 110 feet, drove a Brush generator of 100 H.P. The current was transmitted to the mines by a No. 3 insulated copper wire less than a quarter of an inch in diameter. The length of wire to complete the circuit was 4 miles and 1 furlong. At the mines there was a Brush motor working up to 60 H.P. actual. It drove a ten-stamp battery, and three Huntington mills besides, equal in all to a forty-stamp battery, and there was also a large rock-breaker. In addition, all the mills and buildings were lighted by incandescent lamps by the current taken direct from the transmitting wire. The power required for running the machinery as at present used was from 41 to 43 electric H.P. The electricians present would be able to give their opinion as to whether there could be anything questionable in the results given by these instruments. He had received particulars taken on the 12th of January. At the power-generator there was registered 29 amperes at 1,250 volts, equal to 48½ electrical H.P. The current at the mills at the same time was 28 amperes and the pressure 1,100 volts, equal to 41¼ electrical H.P.; so that practically they were receiving at the mills from 83 to 85 per cent. of the horse-power generated as actual working energy, at a distance of over two miles. They were confidently told by the electricians who put up the machinery, that a wire two sizes larger would give from 2 to 5 H.P. additional; they might therefore talk about 90 per cent. of the horse-power at a distance of more than two miles. Two miners had been instructed, and they attended solely to the machinery where the Pelton wheel and the dynamo were working. Up at the mill there was no supervision whatever of the motor beyond one of the men going in to see that the oil cups did not run empty. The machinery, Mr. Pearson stated, was entirely under control, and in all his experience he had never had to do with a motive power which could compare with it for economy, cleanliness, steadiness, and the ease with which it could be handled.

Dr. LE NEVE FOSTER and Mr. WARREN ROBERTS made some remarks on rock-drills.

Mr. HOLROYD SMITH said the figures which had been given from America with reference to the transmission of electrical energy meant that 15 per cent. was lost in the wires themselves; and for a distance of only two miles such a loss, without some further justification than the saving in copper, was not to be commended. He assumed that the authors when speaking of their percentage of efficiency, and comparing it with that of pneumatic machines, were referring to the power exerted by the steam engine and the power given out in actual work where it was received. On a question of transmission the authors had stated that there was little difficulty in obtaining 50 per cent. of the power expended in the engine. He wished to ask whether that meant indicated horse-power or the power given out by the engine. His own experience had not been such as to enable him to say with certainty that he could expect an engine to lose less than 15 per cent. in itself before it began to give anything to outside work. [Mr. ATKINSON said that the horse-power referred to in the Tables was brake horse-power.] The brake horse-power given out, and the actual work done, were to his mind the points from which they ought to start and at which they ought to end in any calculations of that kind. He thought there was no electrician present who would not much prefer an alternating-current motor if it could be economically constructed, and could be made reliable not only in working, but in the very important point of starting.

Mr. R. E. B. CROMPTON called attention to a diagram of the first electrical coal-cutting machine about three years before the date mentioned by the authors. It consisted of an oscillating arm furnished with cutters, and mounted on a vertical spindle, so as to oscillate through a stroke of from 5in. to 8in., and worked by a pair of electro-magnets. The next point to which he wished to draw attention was the moderation of the language used by the authors when comparing the efficiency of electrical transmission with that of compressed-air transmission. He agreed with several speakers that nothing was to be gained by overstating the case, but he thought that those who were conversant with the use of electricity would agree with him that the authors had, if anything, erred on the side of moderation. He was surprised to hear them say that their percentages were taken on the brake horse-power. He thought that they had taken them on the indicator diagram, and even then he was prepared to substantiate them. He was quite certain, therefore, that they had allowed an ample margin, and that electrical engineers ought to be able to carry out, and more than carry out, all that had been said with regard to the transmission of power up to the distances named. Professor Lupton had thrown down a challenge to electrical engineers which he believed had been taken up by one or two gentlemen present. But it had already been taken up in a much more practical form, namely, by the supercession of air-transmission plant all over the country. This was being done to a large extent in South Wales, and he believed that in a few years the transmission of power by compressed-air would be nearly obsolete. Reference had been made to the cost of repairs for electrical-transmission plant as compared with compressed air plant. The one complaint that the owners of the latter had made to his firm was the great expense of the up-keep. It was costly in two ways—first, on account of its being so inefficient: that portion which answered to the generating plant—the steam-engine and boilers and the air-compressing pumps—was from two and a half to three times as big as was necessary for the electrical plant, and the expenses of the up-keep were proportionately increased. Then there was also the interest on the money invested, and not only was the prime cost greater, but more space was taken up by the machinery. He had carefully gone through the figures presented by the authors, as to the comparison of the first cost of air transmission plant with electric-transmission plant, and he unhesitatingly stated that they were correct and moderate. They had left out one important item that ought to have been put in, namely, the cost of the boiler-power necessary, which, in the case of air-transmission plant, was nearly three times as much as was required for electrical transmission. He had heard with considerable interest the remarks of Prof. Forbes as to the extraordinary dangers which he foresaw in the use of electrical machinery in fiery mines. Prof. Forbes had apparently overlooked one important matter. It was true that, however carefully they might guard against the danger of the communication of the sparks inside the casing to the explosive gases, there was some risk. He admitted it, but it would always be so wherever machinery was introduced into mines. They could not work any kind of coal-cutting machinery without the possibility of the steel points coming into contact with some material harder than the coal, and so causing sparks. Explosions might be produced in that way. He thought, however, that the risks from such a cause were greater than they would be from sparks communicated from the commutator in carefully-devised casings such as the authors had recommended.

Mr. ARTHUR SOPWITH felt certain that a much lighter machine, although at a great sacrifice of power, would gain so much in portability and convenience, that in the long run it would do as much work as a big one. The principle of what was known in America as the Electro-Magnetic Reciprocating Machine appeared to him to be certainly applicable to drills. In it, a bar was drawn into a coil by the action of a current, and brought back again either by springs or by its own weight when the circuit was broken. The great point was the question of the make and break; but if a generator was constructed by which rising and falling currents were created in a closed circuit, the work was done without any possibility of sparking. He thought there should be no difficulty in designing a coal-cutter upon the same principle. It might be said that it would not be easy to construct a machine which would do anything like the same amount of work; but then it would have all the advantages of simplicity, and the absence of movable parts subject to wear and tear. In his case he had used, although not for conveying power, a quantity of old iron and old wire-rope instead of coper, the resistance being only one-twenty-fifth ohm per 1,000 yards, and the cost, including insulation, the same as that of a copper cable of nineteen-sixteenths of good insulation. The relative economic value of iron to copper was as 5 to 1, so that at all events there was room for allowing five times the amount of current at the same expense He mentioned it because it had impressed itself upon his mind, especially as he had tried an experiment with laying wire-ropes side by side on the floor of a coal-mine, and found that, practically, there was no leakage at all, the coal-dust being a perfect insulator. Certainly great economy might be effected by the use of such conductors for conveying the current to centres of distribution in a mine.

Mr. SYDNEY F. WALKER agreed with the authors up to a certain point. As to the important question of sparking, he had repeatedly expressed his opinion, before mining institutes, that the sparking at the commutator was not dangerous, and would not fire gas, and he still adhered to that view, for the following reasons:—First, he had discharged ordinary coal-gas over an old series commutator 10 years ago, and could not get the slightest sign of ignition. Then it should be borne in mind that in order to produce ignition the spark must pass through the gas, and he would ask whether a revolving armature did not create something like a vacuum in the neighbourhood of the commutator, which would keep the gas out. He had another and a much stronger argument which had come to him only recently. Petroleum gas, he understood, was much more inflammable than ordinary coal gas. The chief engineer of a petroleum steamer had told him that he had a dynamo working in their pump-room which was always full of petroleum vapour, into which it was dangerous to go with a naked light; but there had not been the slightest sign of ignition. At the same time, Mr. Walker realised, with the authors, that if there was any feeling among the mine owners that the danger existed, that feeling must be respected and provided for. He did not think that their cover was of the slightest value, for they could not bottle up a spark; the proper course was to get rid of it. There were two points where the spark might be—one at the switch, and the other at the commutator. It appeared to him that there was no reason why the switch need be in gas at all. It could be put in the engine-house, or at any convenient point, with an ordinary electric bell signal between it and the motor station. With regard to the motor itself, his view was that where the gas had to be provided for, and there must be no sparks, there were three ways out of the difficulty. If the alternate-current motor proved itself a success, that was evidently the machine of the future for all work of that kind. The second way was the one which Mr. Sopwith had mentioned

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and which he thought could be arranged very simply, and worked by an alternate dynamo from the engine-house or by reversing gear in the engine-house near the dynamo. The third way was to reduce the spark at the commutators below the firing point. He thought it was clearly proved by experiments that had been made, some by himself and some by Mr. Mordey and others, that it was not a spark *per se* that ignited the gas, but a spark of a certain energy ; there must be a current of about 10 amperes, and, at any rate, a pressure of 2 volts. If, therefore, they could construct a motor so as never to have a spark with a pressure of 2 volts at the brush, including self-induction and everything, it would be harmless. That was simply a question of construction and of size. Like Mr. Sopwith, he strongly advised that the tension in a mine should be kept low. He was aware that, at the present moment, both pumping and hauling were being done with 300 and 500 volts, and no serious harm had resulted. As to the gearing, the whole thing appeared to him to lead to low voltage, which would enable them to go at a slow speed. Everyone knew that the gearing was one of the difficult points that electrical engineers had to deal with ; and for that reason, and also on account of the danger of shocks, he strongly advised that the motor should be made as large as possible and with a low voltage. Though the copper in the cable would be larger, the interest on the money spent on it would be more than made up by the decreased cost of maintenance.

Mr. REGINALD BOLTON gave a few diagrams with reference to the question of percussive rock drills in order to illustrate the particular duties required of them.

Prof. HENRY ROBINSON had carried out works for compressed air at Birmingham on a somewhat large scale, and some experiments were made last year with a view of ascertaining as nearly as possible the efficiency of the system. There were 34 motors worked by compressed air at 45lb. above atmospheric pressure, and it was found that the average efficiency of them was 42·66. When he said the average efficiency, he wished it to be understood that the fittings of some of the motors were very imperfect, so that the results were lower on that account. It was only right to say that in some cases the air, besides being used expansively, was heated before utilisation, which was, of course, an important feature. In many instances, however, waste heat was employed, so that it did not cost the manufacturer anything. But taking the bad with the good, the average efficiency was 42·66. Within a short time after those observations were made the most defective motors were altered, and the working parts modified so as to give better results ; and, as far as he had been able to ascertain, the average efficiency had been raised to 45 per cent. In another case a 40-horse engine, worked by compressed air, was experimented on very carefully, and the air was heated to 280deg., and the efficiency in that case was found to be 73 per cent. Those figures might be taken as accurate, and he thought they should be recorded. When he heard of the average efficiency of compressed air being as low as 20 to 25 per cent., he felt that those who were not familiar with the subject might receive an erroneous impression. For example, in the Birmingham works at the central station installation, in one corner of the site there was a small 200 H.P. engine, which was used during the laying of the mains for testing, and in another part there were three triple-expansion high-speed engines of 1,000 H.P. each. If diagrams were taken from the old type, no doubt they would show a very low efficiency, but it would not be right to take the average efficiency of the old, badly constructed 200 H.P. engine, and the good modern engines, as a fair representation of what compressed air would do. It was, therefore, desirable to avoid coming to the conclusion arrived at by the authors, and he thought that the tables they had given were rather hard upon compressed air. He had examined collieries under different conditions, and was quite certain that he would never advise the introduction of a motor on a system which would increase the risks in fiery seams.

In answer to Mr. Ll. B. Atkinson, Prof. ROBINSON said the 73 per cent. meant the total efficiency from the engine to the motor, including the waste in the motor.

(To be continued.)

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *October* 8, 1891.

Official Report on Electrical Executions. — The official report of the details of the electrical executions at Sing Sing prison on July 7th last has just been given to the public. It is signed by Drs. C. F. MacDonald, and S. B. Ward, the official physicians in charge of the executions. These authentic details differ in some respects from the reports published at the time. The principal fact to be noted is that in no case were the vital functions immediately suspended, although there was not the slightest doubt that each of the victims was instantly and permanently rendered unconscious. Dr. MacDonald expresses the opinion that the law fulfils its purpose of producing immediate and painless death. There were several distinct shocks applied in each case, lasting from 10 to nearly 30 seconds each. The first contact in each case varied from 10 to 27 seconds, and produced instantaneous and complete unconsciousness with cessation of respiration, but did not destroy the action of the heart. In one case respiration began to be re-established, but was instantly checked on again applying the current. The voltage was from 1,458 to 1,485, most of the time at the latter figure. There was but one elaborate post-mortem examination, and that disclosed nothing of special importance. A strong effort will be made to secure the repeal of either the law itself or that portion of it which forbids the publication of the particulars of the executions. It may be that the cases brought by the district attorney against the editors of several of the New York morning papers will be brought into play to test the constitutionality of this provision of the law.

Statistics of Street Railroads—Some interesting statistics on the subject of electric street railroads have been recently published in one of the journals here. The total number of miles of street railway in the United States and Canada is 11,029, of which 5,442 is horse railroad, 3,009 electric road, 1,918 miles of steam street railroad, and 660 miles of cable road. The horse roads operate 25,424 cars, the electric roads 6,732, the cable roads 3,317, and the steam roads only 1,044, making a total of 36,517 cars. There are 412 electric roads, and the result of the remarkable growth in their number has been, that the number of horses employed on street railway lines has, since November, 1890, decreased by nearly 30,000. Four hundred and twelve is probably rather a high estimate for the electric roads actually in operation, as some of those enumerated are under construction, and others have not yet completed—in some cases have not begun—the change from horses to electricity. Still one can safely say that there are very nearly 400 electric roads in present operation in this country. The number of cars given is in all probability very nearly correct.

The American Street Railway Association.—The meeting of this Association at Pittsburgh, beginning October 21st, will be of great interest to the electrical fraternity at large, inasmuch as the list of Papers to be read deals exclusively with electrical subjects, except for a single discussion of the relations between corporations and the public, which would be equally appropriate in a meeting of the Electric Light Association. Some exceedingly practical Papers will be read, and the meeting promises to be a most interesting one.

BRUSSELS NOTES.

(FROM OUR OWN CORRESPONDENT.)

BRUSSELS, *October* 12, 1891.

The following is an extract from the report recently submitted to the Brussels Communal Council so far as it relates to electricity :—

The proposals to grant a concession for the distribution of electricity in this town has been examined by the Commission, but before taking action it was deemed prudent to obtain more exact information as to the probable cost of a system of electric distribution by the municipal authority a contractor being responsible for working the same, at first. Accordingly a fresh estimate has been prepared, and tenders are invited for the work, which should be sent in not later than October 31st.

During the past few months the cables supplying the lighting current to the Theatre de la Monnaie, the Town Hall, and La Grande Place have been thoroughly overhauled, and some important repairs have been effected, especially at the joints. Inside the theatre it has been found necessary to rebuild the electric organ and to remove nearly all the circuits from the stage, in order to make provision for a metallic curtain.

The "20 kilos" accumulators continue to do very good work ; the usual rate of discharge is $\frac{3}{4}$ ampere per kilo of plate, and it is only on rare occasions that the maximum of $1\frac{1}{2}$ amperes is reached. Under these conditions the cost of upkeep is very small.

The telescopic electric lighting poles in La Grande Place still attract much attention and but little favour. The matter is at present in abeyance, and will be dealt with later on.

There are 18 offices devoted to telephonic and telegraphic work in this town, and these offices are connected by 30 wires. The Compagnie du Telephone Bell have for the use of its subscribers 1,325 lines, and, in addition, there are 12 private wires.

Fire alarms are fitted to 44 of the principal buildings of the town. There are also 410 electric clocks.

At the beginning of August 16,500 metres of the old iron wire had been replaced by lines of phosphor bronze.

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CORRESPONDENCE.

TEMPERATURE CO-EFFICIENTS FOR CORRECTING THE RESISTANCE OF WILLOUGHBY SMITH'S GUTTA-PERCHA TO 75° FAHRENHEIT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: To nearly all text books connected with the electrical tests applied to submarine cables are appended tables of co-efficients for correcting the dielectric resistance from any temperature at which the test may be taken to 75° Fahrenheit, the standard temperature for such tests. It is to the table given in Kempe's "Handbook of Electrical Testing" for correcting the resistance of Willoughby Smith's gutta-percha that the following remarks refer, as the core upon which the observations were made was composed of that material.

On a previous occasion it had been noticed that when testing cable at a low temperature on applying the co-efficient from the above-mentioned table that the resistance at 75° Fahrenheit fell also as the temperature fell. While on a voyage recently from Singapore to New Zealand and back an attempt was made to arrive at a set of co-efficients which should be more nearly correct than those at present in use apparently are. The core of the cable which was experimented upon was composed of 107lbs. copper and 140lbs. Willoughby Smith's gutta-percha, and was 30 miles in length.

Tables No. 1 and 2 give the results of two sets of tests on this piece of cable; No. 1 while going south and decreasing the temperature, and No. 2 returning north and increasing the temperature.

Table No. 3 is a comparison of the co-efficients usually employed and an approximate set based on Table No. 2. I have worked on this latter, as on the whole I think the tests were taken under better conditions of weather, steadiness of ship, &c. It will be seen that results at same temperature vary a little in the two tables; but the difficulty of reading a thermometer to a quarter of a degree, and the galvanometer scale to, say, half a division will, I think, account for this, more especially as the majority of the tests were taken at sea, under conditions of ship rolling or pitching, occasional trouble from dampness in testing room, &c.

I merely put forward as approximate the last column in Table 3, to show the great difference between the present co-efficients and the results I obtained. It may be mentioned that for temperatures above 75 deg. by applying the usual corrections the result gradually increases with the temperature.

If some of your readers who have the leisure and appliances were to investigate this matter, by means of a series of tests under favourable circumstances, I imagine a reliable set of co-efficients differing considerably from the present ones would be the result.

I shall be interested to see if any one has already gone into this matter, and, if so, what was the result of their observations.

Trusting you will find room for this letter in your paper,

I am, &c.,

A. C. M. WEAVER,
Eastern Extension Telegraph Co.'s
Cable Ship "Recorder."

Singapore, Sept. 8, 1891.

Table No. 1.

Temperature Fahrenheit.	Megohms per kilowatt at observed temperature.	Megohms per kilowatt corrected to 75° Fahrenheit by usual co-efficient.	REMARKS.
83·5	303	523	
82	327	515	
81·5	323	490	
80	332	460	
75	455	455	Taken at sea.
73	470	403	
69	486	305	N.B.—Nearly all these tests taken while ship unsteady.
68·5	510	309	
68	515	300	
67·5	519	291	
66	564	281	
63·5	585	240	
62	630	230	

Table No. 2.

Temperature Fahrenheit.	Megohms per kilowatt at observed temperature.	Megohms per kilowatt corrected to 75° Fahrenheit by usual co-efficient.	REMARKS.
57	730	181	
59·5	701	211	
63	619	244	
64·75	610	275	Ship rolling.
66	594	296	
67	566	304	
68	548	319	
68·75	528	325	
70	493	334	Ship fairly steady
72	467	370	
73·75	447	406	
75	427	427	Ship steady.
76	401	428	Ship unsteady.

Table No. 3.

Temperature Fahrenheit.	Usual co-efficients employed.	Co-efficients based on Table No. 2.
57	4·029	1·710
59·5	3·320	1·642
63	2·532	1·449
64·75	2·211	1·429
66	2·007	1·391
67	1·858	1·326
68	1·719	1·283
68·75	1·622	1·231
70	1·473	1·155
72	1·261	1·094
73·75	1·101	1·047
75	1·000	1·000
76	·9375	·9391

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

NOW READY.—"THE ELECTRICIAN" PRIMERS (38 in all. Vol. I., 20; Vol. II., 18), in two volumes. Price per volume 2s. paper covers, 2s. 6d. cloth; post free, 2s. 2d. and 2s. 9d. respectively. Single copies, 3d.; post free, 3½d. Prospectus on application to the Publisher.

TENDERS RECEIVED.—The following tenders were received by the London County Council for providing electric light at the Newington Weights and Measures office:—Messrs. Crompton and Co. (Limited), £182. 17s. 10d.; Brush Electrical Engineering Co. (Limited), £150; Messrs. Drake and Gorham (accepted), £143.

SALES BY AUCTION.—Messrs. Wheatley Kirk, Price, and Goulty announce in our advertising columns that they will sell by auction, on Thursday, October 29, 1891, the entire contents of the premises 323D, Kennington-road, London, S.E., including a 10 H.P. and a 4 H.P. horizontal steam engines and vertical multitubular boilers, several lathes and other machine tools, pulleys, shafting, belting, &c.

——— Messrs. Wheatley Kirk, Price, and Goulty also announce an important sale, at 39, Queen-street, London, E.C., early in November, of a large variety of new electrical apparatus, including also the entire stock of the West-End Electric Supplies Company, comprising about 50 miles of cable, leads and wires, several thousands of fancy shades, 50 arc lamps, 150 volt and ammeters, 10,000 switches of every variety, 10,000 fuse-boxes and fuses, 10,000 ceiling roses, several thousands of lamp-holders, 1,000 incandescent lamps, several thousands of plain and fancy brackets, electroliers, shades and fittings, Leclanché cells, bells, insulators, carbons, &c., several dynamos, engines, switch-boards, 100 accumulators, electroliers, &c. Full particulars and catalogues may be obtained shortly from the auctioneers, 52, Queen Victoria-street, London, E.C., and Albert-square, Manchester.

MESSRS. NICHOLSON AND JENNINGS.—This firm, trading at 13, Victoria-street, and 132, Horseferry-road, Westminster, London, S.W.; Royal Exchange-buildings, Queen-street, Newcastle-on-Tyne; and Blyth, as electrical engineers and contractors, have made an assignment of their property (filed October 8th) for the benefit of their creditors. Messrs. Edmund I. Bax, 32, Victoria-street, Westminster, S.W., and William C. Mann, 112, Belvedere-road, Lambeth, S.E., are the trustees. The secured liabilities

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amount to £300, and the unsecured to £4,992. 8s. 9d.; while the net assets are £5,705. 18s. 6d. The following is a list of the principal creditors:—

Belfast Electrical Appliance Company ...	£21	0	0
Cowpen Local Board, Blyth	12	0	0
Saunderson and Co., Blyth	52	0	0
A (?), Berlin	92	0	0
Alliance & Consumers' Gas Co., Dublin.....	1,035	0	0
Every, J., Lewes	48	0	0
Brush Electric Engineering Company ...	1,534	0	0
Callender and Co.....	99	0	C
Cooper, W. B. D.	125	0	0
Edison & Swan United Electric Lighting Co. (Limited)	49	0	0
Electric Construction Corporation (Ltd.)...	108	0	0
Electrical Engineering Corporation (Ltd.)...	141	0	0
Engelbert and Co.....	29	0	0
Faraday and Son	12	0	0
Furber, Price & Furber	250	0	0
General Electric Company.	27	0	0
Gill, A. B., and Co. ...	£18	0	0
Lacombe and Co.	10	0	0
Ley, H., and Sons.....	24	0	0
Maude and Tunnycliffe (?)	15	0	0
Monkhouse, E. W.....	12	0	0
Mutual Tontine.....	19	0	0
Nalder Brothers	82	0	0
Pattison and Co.....	50	0	0
Pettengill, J.	150	0	0
Phipps and Connor	10	0	0
Planet Electrical Engineering Company (Limited)	10	0	0
Poole and White (Ltd.)	12	0	0
Smee, London	15	0	0
Telegraphic Company (Limited) (?)	443	0	0
Vigers Brothers.....	12	0	0
Westminster Electric Supply Corporation.	471	0	0
Wilcox and Co.	116	0	0
Woodhouse & Rawson	14	0	0
Reid, A., and Sons, Newcastle-on-Tyne..	31	0	0
Lea and Sons, Shrewsbury	11	0	0

SILVERTOWN CABLES.—We have received a very full price list of these electric light cables and wires. A large number of classes are offered, and against each of these a brief specification of the insulating materials is given, together with the insulation resistance. As much of the success of electric light cables and wires is dependent on the uniformity of manufacture and quantity and quality of material used, to ensure these conditions the makers have made it a practice to thoroughly test all cables and wires supplied, and have decided in future to issue with every length of not less than 110 yards of vulcanised india-rubber insulated cable or wire of their standard classes, a label giving the minimum insulation resistance (after twenty-four hours' immersion in water) of such cable or wire, per mile, at 60°F. This test is carried out with a battery of 450 volts, and is calculated to break down any faults in the cables should they exist. Lead-covered cables are supplied, and we observe that the insulating materials are the same in these as in the corresponding classes, no advantage being taken of the lead covering to make use of inferior or non-waterproof insulation.

BUSINESS CHANGES.—Messrs. Cuénod, Sautter and Co., the well-known electrical engineers of Milan, have dissolved partnership, and the business has been transferred to the Société d'Appareillage Électrique. This Company, with a view to the development of their business, has been reconstituted under the title of Compagnia dell' Industria Elettrica Ginevra, with works at Geneva and a branch at Milan. Signori H. Cuénod and René Thury remain with the new Company at Geneva as technical director and electrical engineer, and Signor J. Cuénod takes charge of the Milan branch.

WALSALL ELECTRICAL COMPANY.—We have received an intimation that the partnership previously existing between Mr. Frederick Brown and Mr. Howard W. Bishop, trading as the Walsall Electrical Company, has been dissolved. All moneys due to the firm will be received, and all outstanding accounts will be paid, by Mr. Frederick Brown, who is now carrying on the business under the old style and title.

MESSRS. MORGAN WILLIAMS AND KING.—This firm are superintending an electric light installation at the Mansion, Doublebois, Cornwall, for which Mr. F. M. Newton, of Taunton, is the contractor. Messrs. Williams and King are also superintending the erection of a complete electric light installation at the new parish church, Hove, Brighton.

GÜLCHER (NEW) ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—We are informed that during the last six months the Gülcher Company have made considerable business progress. Mr. De Castro, Chairman and Managing Director, who has visited New Zealand, has succeeded in largely extending the business of the Company in that colony. The Wellington-street lighting installation, which has been working satisfactorily for three years, is now to be extended to include the supply of about 3,000 lamps to private consumers. Bills have passed through the New Zealand Parliament for the lighting of Christchurch, and other important towns will shortly follow. General installation work undertaken by the Company in New Zealand is also largely increasing. An important order for a central station, with plant for a first instalment of about 2,600 incandescent and 60 arc lamps, has been secured, and will very shortly be in operation for lighting part of the city of Genoa, Italy, where a branch establishment of the Gülcher Company has been opened. In London, also, the Company are busy with installations, including the lighting of the People's Palace at Mile End-road, and a large contract was recently secured for the lighting of "Modern Venice" at Olympia, West Kensington. The Company have lately opened a show-room and offices at 139, Queen Victoria-street, E.C., and we congratulate the Directors upon the general progress shown. The successful installations at the recent Spanish, French, and German Exhibitions at Earl's Court, coupled with energetic management, have doubtless assisted in bringing about this gratifying change in the fortunes of the Gülcher Company.

THE PELTON WATER WHEEL.—Messrs. Fraser and Chalmers (Limited) have been appointed the general representatives for London and the English trade generally; but we understand the arrangement with them contains a clause in favour of Messrs. Woodhouse and Rawson United (Limited), who will handle the wheels and motors for electrical work. Mr. A. P. Brayton, President of the Company, who was recently in London, complains of the fact that the Company's patents are being infringed in this country, and informs us that he is taking steps to protect same. The Company contemplate a considerable business in Great Britain and on the Continent for their wheels and motors.

ZÜRICH INCANDESCENCE LAMP COMPANY.—We have received neatly printed particulars of the various sizes of lamps made by this Company, accompanying which are some useful tables and a coloured plan of the Frankfort Exhibition.

JENSEN BELLS.—We are informed that Messrs. Hans Peter Frederick Jensen and Jens Jensen, who have hitherto been branch managers of the business carried on at No. 2, Gray's Inn-road, W.C., under the style of "The Jensen Electric Bell and Signal Co.," are no longer connected with Woodhouse and Rawson United, Limited, and that they are not authorised to transact business on their behalf. In the course of the present month the business will probably be removed to the Cadby Hall Works, Kensington, and sales will be made from the head office, 88, Queen Victoria-street, E.C. Of the date of this change notice will be given.

THE MAQUAY ELECTRIC LIGHT COMPANY.—We are informed that this Company have received a number of considerable orders for their system of electric lighting by small primary batteries; a description of the battery was given in a recent issue of *The Electrician*. The Company have received an order from the Government to make a battery for driving launches for 10 hours; and amongst other considerable orders which they have received is one for £260 from a firm of bicycle makers for small electric lamps for bicycles.

THE FOWLER-WARING CABLES COMPANY.—The District Messenger Service and News Co. (Limited) have just concluded a contract with the Fowler-Waring Cables Co., for the supply of 100 miles of wire for their messenger service. The whole to be delivered by the early part of the forthcoming year.

MESSRS. BARCLAY AND SON.—The electric light installation at the London mansion of Mr. L. de. Rothschild in Hamilton-place, Park-lane, has been entrusted to Messrs. Barclay and Son, of Regent's-street. The plans have been prepared and the work is being carried out under the superintendence of Mr. John Archbutt, the engineer to the firm. There are to be 600 lights—400 in the mansion and 200 in the garden and conservatories. The main cables for the house and garden are being supplied by the Fowler-Waring Cables Co. (Limited), and the whole of the fittings are being specially designed and manufactured by Messrs. Barclay.

ELECTRIC INSTALLATION AND MAINTENANCE COMPANY.—The system of direct current transformers is that to be adopted in the Sydenham and Crystal Palace district. Mr. Frank King (of the firm of Messrs. Morgan Williams and King) has been appointed Consulting Engineer to the Electric Installation and Maintenance Company (Limited), who are the holders of the Provisional Order, Messrs. J. E. H. Gordon and Co. (Limited) being the contractors.

MESSRS. JOHN TULLIS AND SON.—We have received from this firm a copy of their "Guide to Belt Driving," of which four editions have been issued. There is a deal of useful information on the subject of belt driving in the 58 large pages of closely printed matter, and there are a number of illustrations. The book is published by Messrs. Tullis and Co. in German, French, Spanish, and Portuguese, copies of which can be obtained on application.

ALLIANCE ENGINEERING WORKS, WEST DRAYTON.—These works were put up for sale at the Auction Mart, on Wednesday, by Messrs. Hobson, Richards and Co., but there were no bidders.

COPPER.—Messrs. Thomas Bolton and Sons inform us that in future all their H. C. copper will be guaranteed to have an electrical conductivity of not less than 100 per cent. of that of pure copper, according to Matthiessen's standard.

MICA.—A discovery of mica in the Ixopo divison of Natal has, it is stated, attracted some attention in the colony.

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PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

September 20, 1891.

15,922. R. HADDAN. London. Improvements in electrical incandescent lamps. (G. Dedreux, Germany).

15,937. J. C. FELL. London. Improvements in electrical measuring instruments. (E. Weston, United States).

September 21, 1891.

15,953. J. H. BARRY. London. Electropathic massage, appliances therefor and for other purposes.

15,980. J. G. S. CUNNINGTON. London. An improved form of carrier for shades and globes for gas and electric light.

16,006. W. H. R. SAUNDERS and W. GRIFFITHS. London. Improvements in electrical insulators.

September 22, 1891.

16,038. A. MARR. Manchester. Improvements in telephonic receivers which may also be used as transmitters.

16,076. J. WRATITSCH and S. GERGACSEVICS. London. Automatic coin-freed telephonic machine.

16,080. M. S. CONBY. London. Improvements in governors for dynamo electric machines.

16,087. J. H. FURMAN. London. Improvements relating to electrical traction.

16,099. C. S. BRADLEY, R. S. TAYLOR, and R. T. M'DONALD. London. Method of and apparatus for converting the electrical energy of alternating currents into mechanical motion.

16,110. W. P. THOMPSON. Liverpool. Improvements in, or connected with, automatic regulating devices, and in electrically actuated pointer mechanisms applicable therefor, and for other purposes. (The Firm, Willing and Violet, Germany).

16,113. T. H. O'BRIEN and C. O'BRIEN. Manchester. Improvement in suspenders or hangers for electric lamps, applicable also for other articles.

16,119. J. B. CARTER. London. Inprovements in electric switches.

September 23, 1891.

16,130. F. E. BEETON. London. An arrangement to regulate the potential of dynamos.

SPECIFICATIONS PUBLISHED.

1890.

14,196. LAKE. (Tibbits). Incandescent electric lamps. (Price 8d.)

16,110. PARKER AND OTHERS. Distributing electricity. (Price 8d.)

16,613. MÜHRLE. Incandescent lamps. (Price 8d.)

17,108. PITT. (Thury). Dynamo electric machines. (Price 8d.)

17,486. ATKINSON, C. W. AND L. B. Magnetic separators. (Price 8d.)

17,940. SIEMENS BROS. and Co. (Siemens and Halske). Arc lamps. (Price 8d.)

18,088. KINGSBURY. (The Western Electric Company). Telephonic switch boards. (Price 1s. 1d.)

18,969. PRICE and GRAY. Measuring resistance, &c., of electric conductors. (Price 6d.)

20,321. STOVELL. Lighting tables, &c., by electricity. (Price 8d.)

1891.

7,949. GOWARD. Secondary batteries. (Price 8d.)

11,134. FAURE. Electrolysis of chloride of aluminium. (Price 8d.)

12,117. HARTMANN and BRAUN. Electric current meters. (Price 8d.)

12,257. SCHARF and LATZKO. Electric incandescent lamps. (Price 8d.)

12,960. MORDEY. Electric transformers. (Price 8d.)

13,315. JOHNSON. (Bellens). Arc lamps. (Price 8d.)

COMPANIES' MEETINGS & REPORTS.

City of London Electric Lighting Company (Limited).

The first ordinary general meeting of this Company (being the statutory meeting required to be held within four months after the registration of the Company) was held yesterday at Winchester House, Old Broad-street, under the presidency of Sir David Salomons, Bart.

The SECRETARY (Mr. J. Cecil Bull) having read the notice calling the meeting,

The CHAIRMAN said: At this meeting, which is the statutory meeting as required by law, no business whatever has to be done, and, strictly speaking, if your time were of great value, I might sit down and proceed to the resolution referring to the alteration in the Articles of Association. I presume, however, that you would like to hear something about what we have been doing. In the first place, to go back shortly over the history of this Company, Provisional Orders were granted and afterwards confirmed by Parliament, for the Eastern, Western, and Central Districts to be lighted by two companies—one, the Brush Company, which was to take over the Central and Western Districts, and the other the Laing, Wharton, and Down Company, who were to take over the Eastern District. The Brush Company have also the Southwark district, a very small one, but of great importance to us, as our station is situate in that district, and we have to traverse it and by the bridge get into the City. In regard to the Western District, nothing has been done at present in consequence of the Order having been granted considerably later than the others. The Central and Eastern Districts are those upon which we have begun to proceed with work. The orders would have fallen in, and the whole of the labour of obtaining them would have been lost but for the formation of the Pioneer Company, which began the work, and the concessions which had been granted have consequently been thus kept alive. The Brush Company and the Laing, Wharton, and Down Company have not large capitals available for the lighting of a place like the City of London; and it was, therefore, necessary to find financial means to carry out the work. The Pioneer Company, with a small capital, was first started, and time was thus allowed for the formation of a larger Company, which is now the City of London Electric Lighting Company. The Pioneer Company sold, under certain conditions, the whole of their rights, having taken the whole of the risk at the outset, to this Company, and hence the position in which we stand to-day. Now, of course, a certain feeling exists on the part of customers for the electric light—I know it from my own experience in the West End. The moment a company was declared to be formed for supplying a certain district, an application was sent in by me for the light; and I hoped that on the following day the wires would be put into communication with my house; and no doubt the same feeling is held in the City, judging by the orders that come in. It was only on August 21st, however, that we obtained the sanction required for the transfer of the whole of the powers of the Pioneer Company to ourselves from the Board of Trade, and we also had to have the assent of some of those to whom we are contracting—the Commissioners of Sewers of the City, for instance. Therefore it was only from August 21st last that we really got to business. It is our intention to keep everything in the open—not to do anything underhand—and to do everything in the best possible manner, so that every economy and efficiency may be practised, while nothing is hurried, so as to avoid our having to do anything a second time. All those who have made applications to us for the light must, therefore, have a little mercy with us, and give us time to carry out the work properly, rather than be sufferers through working us too hurriedly. As those who have read the prospectus are aware, the final equipment will be 400,000 eight-candle glow lamps for private lighting. We are supposing that 80 per cent. only will be in use at any one time, and practice has shown that that is a reasonable view. The underground work is extremely difficult in the City. Every hole and corner below the ground is occupied with iron pipes of some form or other, water mains, hydraulic, and gas pipes, pipes for the telephone, for Post Office wires, and a variety of other matters, which one would little dream of until digging up the streets. The difficulty and expense in the City will therefore, be considerably heavier in consequence of the ground being so much occupied, than would be the case in West-End streets or in country places, where there are not these difficulties. I point this out now because comparisons will, no doubt, be made later on, and the expenses may be considered excessive. I hope they will work out smaller, but should they appear larger than that incurred in other districts in putting down conductors and conduits, it will simply be through these difficulties that I have mentioned, as there are not subways throughout the City. The system to be employed by us is a very safe one. There are to be no transformers in the houses that are lighted. There are to be sub-stations, to which, say, 8,000 or 10,000 lamps will be appropriated; and from these points to the head station there will be a high-pressure current, delivering at about 200 volts. This is dangerous to life, but it has been tried on a large scale in London and elsewhere, and has always been successful. It is not an unreasonable pressure like some of the other companies have been trying. The delivery from some of the stations will be at a lower pressure—a little over 100 volts, or a little more than that, so as to allow for loss. There need, therefore, be no fear about any customer having a shock or being killed, for there will not be the least danger in the world. I think this statement will give confidence to a great many customers who otherwise might feel nervous when they hear about the high-tension currents that are sometimes spoken of. The arc lighting will be on the continuous system, part of the district being lighted by the Brush system and part by the Thomson-Houston system. Both of them are very good, and I do not suppose from the gentlemen employed in carrying out the work, that there will be any failure of any kind excepting at the start, perhaps, when little difficulties nearly always occur. In Queen Victoria-street there are now 26 arc lamps at work, but as the lamp-posts have not yet been passed by the City Engineer, we cannot proceed with that work until it is absolutely settled. As soon as the matter is approved, the final posts will be erected. Still, 26 lamps are running for the time being. We have already had as many as 200 applications—just upon that number, a few under or over—for private use; and assuming from the size of houses in the City—which are not like ordinary private houses, but consist of offices—assuming 200 lights to every building, about 40,000 lamps have thus already been applied for. These applicants have not stated their numbers yet, but very shortly a proper form will be issued to them to be filled up, stating exactly what the requirements of the applicants are, so that we may know how to supply them properly. It may interest you to know the

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class of persons from whom these applications have been received. They include the Post Office, the Mansion House, the Guildhall, banks, offices, and such like; so that, at any rate, large public concerns seem already to put some faith in us, and I trust that this will be continued, and that we shall be able to maintain their confidence. If all goes well it is expected that by the end of this year private lighting on a small scale will be started, but it is dangerous to promise anything by any date. I think it was promised—though not by this Company—first by August and then by November, and now I have just said that it will be started by the end of this year. If it is not quite ready by the end of the year, I hope that very soon afterwards it will be ready. As you are aware, when the Company was brought out, times were not promising in any way. There had been great trouble in the City, and we hardly expected to get anything like the support we received, which was for slightly over three-fourths of our whole demands. Money is not wanted for the moment, but it will be as the work proceeds, and we shall then issue the remaining one-fourth. The Board have under consideration whether they shall not offer the remaining capital first to the shareholders at a small premium. In the prospectus you will notice that a certain sum was reserved on the part of the Pioneer Company to pay the expenses of issuing this Company. In consequence of the whole of the capital not having been allotted, and in consequence of other economies, there will be an extra sum of £6,000 placed to our credit. To-day we have done very good work at our Board meeting, which has come to the climax after a considerable amount of examination, which is necessary in connection with the expenditure of large sums. The final order has gone forth for the wiring of all the chief districts in the City, and by the end of next year it is to be hoped that not only will all these districts be completed, but also the greater part, if not all, of the public lighting, which will bring us in a considerable revenue. I think I have now given you all the chief circumstances that have occurred in connection with the Company up to to-day. The work is progressing, and it is simply a question of patience and waiting. The only other point that I need mention is in respect to a question that is frequently asked and often answered, but very rarely retained in the mind—that is, what does an electric lamp cost per hour? The answer is, that at the cost of 8d. per unit, which is about the price charged, more or less, over London—and I presume it will be about our price—an eight-candle lamp costs as nearly as possible ¼d. per hour. This is decidedly not an unreasonable sum, for gas at about 5s. or 4s. 6d. would be that amount, and gas has many disadvantages which the electric light has not. Landlords must also bear in mind that by adopting the electric light they improve their rentals to a considerable extent. There are many buildings with cellars—storeys of cellars—in one case I know of three storeys of cellars; and these places are now used for storing wine and beer barrels, whereas, by the electric light, they might be made habitable as offices, which hitherto with gas could not be done. I hope the landlords will take advantage of this, and give us the benefit which we should derive from their using the electric light, especially as they would at the same time be benefitting their own pockets. I do not think that the gas companies need have anything to fear from us. They have been decidedly good-natured to us. They have not raised any difficulty in our way where we have been laying the conduits. The electric light is decidedly a cold light, and people trying it will not use any other afterwards. You see, too, that everything looks clean where the electric light is used. People will use gas stoves to a much larger extent in future, I believe, and in that way gas companies will gain instead of losing anything through the electric light. Where the electric light is used there will not be the present necessity for so many holidays through sickness, and clerks and others will be able to work with clearer heads. We shall in the first instance endeavour to satisfy our shareholders as regards dividend, but we hope we shall be able to satisfy everyone. I am reminded that we found at the outset that it was very desirable to have a few technical points answered. We believed we were right in regard to them, but at the same time we wished to have them confirmed, and as a result we called in Prof. Silvanus Thompson as our consulting electrician; and if any point should arise in electrical matters on which we should feel the smallest doubt, or in any way think it would be desirable to obtain further advice, Prof. Thompson will be asked to assist us, as a gentleman in whom we all have confidence—the Directors, our contractors, and engineers—and we shall work together without the least friction.

Mr. W. W. BRUCE said that there appeared to be an idea prevalent in some quarters that the Company's communications through the streets were better adapted for arc than incandescent lighting. He did not know whether this opinion could be dispelled.

The CHAIRMAN replied that the answer to the question was very simple. Whether it was for arc lighting or the incandescent system it was only a question of putting the tubes in the ground. In Queen Victoria-street, with the subway the difficulty was very small, and provided there was room to get in the tubes no difficulty existed.

A SHAREHOLDER asked how much of the capital had been subscribed.

The CHAIRMAN: £301,000.

A SHAREHOLDER: Can we have a few more shares at par?

The CHAIRMAN said he doubted it. The shares were nominally at a premium that day on the Stock Exchange. If they did not stand at a premium when the time came for issuing the balance of the capital they would not be able to get a premium, but if the price were maintained they hoped they would be able to offer the fresh issue of shares to the shareholders at a premium but giving the shareholders a slight advantage. Continuing the Chairman said: Everything is ready to obtain a quotation on the Stock Exchange except for one little difficulty that has occurred, and the meeting will now be asked to remedy that by passing the following resolution:

"*That Article No. 13 of the Company's Articles of Association be altered by inserting after the words 'each call' at the end of the fourth line the following: 'And that no call shall exceed one-fifth of the nominal amount of a share or be made payable within two months after the last preceding call was payable.'*"

Well, that desire already exists, and is upon the prospectus for the present issue. Therefore, by inserting this we do not alter our position at the present moment, and we shall obtain a quotation on the Stock Exchange. Personally, I do not care twopence for the quotation one way or the other. I only hope that by our obtaining it a great many persons will be given an opportunity of acquiring shares in the Company who have an interest in the subject, and who on that account will support the Directors, and that at the same time an opportunity will be given to those who have simply taken shares in the Company as a financial speculation, and who have no interest in our well-being, to dispose of their holdings. If the result of this alteration will be, as I trust, to get around us a body of shareholders who will take an active and intelligent interest in our proceedings, nothing will give me more pleasure than to see our shares have a Stock Exchange quotation; and if this resolution is passed I believe that that will soon be the case.

On the motion of Mr. BRUCE, seconded by Mr. JOHN MORRIS, the resolution (which was put to the meeting by the Chairman) was carried unanimously.

The proceedings then terminated in the usual way.

Electric Arms and Ammunition Syndicate (Limited).

The first ordinary general meeting of the shareholders in this Syndicate was held on the 9th inst., at Winchester House, Old Broad-street, under the presidency of Major C. B. Waller.

The SECRETARY (Mr. W. F. Branston) having read the notice convening the meeting,

The CHAIRMAN observed that they met in rather exceptional circumstances. A petition had been presented to the Court for the compulsory winding-up of the Syndicate. It had been presented by five of the shareholders, three of whom he did not know personally, the fourth was their late manager, Mr. James Ronald Watson, and the fifth was an intimate personal friend of his own. The petition came upon the Board not exactly as a surprise, because they knew what was going on beforehand, but it was a surprise in this sense—that they were excluded from the deliberations of the gentlemen by whom the petition had been presented. The Directors had opposed it in the interests of the shareholders generally, feeling that no liquidation should take place until the general body of them had had the opportunity of expressing their views on such a course. With the exception of two or three shareholders outside of those who had presented the petition, the Directors had been supported by the whole body, and the matter stood thus—the first hearing took place on the 30th of September; and the Judge, after hearing the arguments of counsel and the various documents produced in the case, ordered it to stand over until after that day's meeting, so that he might hear at the adjournment what the feeling of the shareholders might be. That was what he might call the "political situation," upon which he proposed to offer a few comments later on. Passing to the Directors' report, he stated that the first paragraph referred to the competitions which were instituted at the annual meeting of the National Rifle Association at Bisley, last July. It had been the Directors' intention to make this a considerable demonstration of their system of electrical discharge; and to a certain extent they succeeded. They had intended to have two competitions—one with the Service weapon, the Martini-Henry, and the other with the miniature saloon rifle, which they had made for the purpose of showing how the electrical system worked. It was a question only whether the electrical current sent through their circuit would discharge powder or not, for if it would it mattered little whether the charge was 5 drams of powder in a fowling-piece, or 150lb. in a great gun. The competition, as far as it went, was successful in the sense that several thousand shots were fired. Unfortunately, however, they were unable to use the Service weapon, and they were, therefore, obliged to put all these shots through the miniature weapon. The reason they had not been able to use the Service weapon was that they had expected to receive some months before the Bisley Meeting a primer machine which the American Company had undertaken to supply them with; but delays occurred, in connection with which he would not say who was responsible. Finding that the time was approaching for their demonstration, and that they had not the necessary number of primers for the two rifles, they were compelled, reluctantly, to abandon the use of the Martini-Henry rifle, and to restrict their operations to the little rifle mentioned. Eventually they got the primers sent over from America, because they could not get the machine, and, as a matter of fact, their machine had been retained in America to make these primers. They showed their gun to probably 1,500 or 2,000 of the best rifle shots in the country—the men who generally attended the meetings of the National Rifle Association, and among them were naturally some experts and machine gun makers. Those gentlemen were very much struck by the Syndicate's system of electrical ignition, which was, undoubtedly, the only one of its sort that was ever likely to be a thorough success. The ignition of the powder and the shooting of the gun attracted a great deal of attention, and when the Directors returned to London, and had their late manager's report, he told them how very promising had been the applications made to him by the gunmakers of eminence at Bisley, and gave very great hopes of the future of electrical ignition, and more particularly their own system. At the same time he brought a tale to the Directors that was very disquieting. In the course of the shooting the battery had exploded, and had shattered the wood of the gun. They

were then face to face with an incident which in practice would have proved fatal to their system. They set to work to inquire into the cause of the occurrence, and their investigation showed that the defect which had been developed was in the mechanical construction of the battery cases, and not in the principle of the battery. Their manager was not at all dismayed, but saw that he was face to face with a difficulty, and set himself to work to overcome it. They entered into correspondence with their friends in America, who were very large proprietors in the concern, because their patents were sold to the Syndicate practically for shares, cash being a very small item in the consideration. They made various attempts to overcome the difficulty, and they thought they had succeeded by making a plug of porous material. That, however, failed, and eventually their manager found a gentleman who was working on the same lines as themselves—a man who, from what he (the Chairman) knew of him now, had considerable knowledge of electrical science. Mr. Watson brought them a battery from this gentleman, and it was tested. It had this peculiarity, that it dispensed with the liquid. Their charge was no longer a fluid charge, but a gelatinous charge, and they had not anticipated any bother in making this compound. When they got the battery from him he failed at first—not in the manufacture of the battery, but in one or two details; and, like all men who could only make a thing of this sort by hand, he had to depend very much on what he could get from small dealers, and he had to find out the just proportions of the two elements which made up this jelly. This took him considerable time, but eventually he put half-a-dozen batteries or so in their hands, and they appeared to be just what was wanted. They then put this battery into the hands of one of the most eminent scientists of the day, Dr. Fleming, who examined it with the most scrupulous care, and put it under the most severe tests. Their battery had to give an instantaneous flash and discharge the moment one put one's finger on the trigger. Dr. Fleming eventually succeeded in getting between 7,000 and 8,000 shots out of one of these little batteries, and, more than that, he got some continuous effects lasting some four or five minutes. Dr. Fleming had not yet given them a final report, but he had told him (the Chairman) that he thought the battery was a very remarkable advance on anything he had seen before, and had advised the Directors that it was worth prosecuting. The Board felt that they were justified in testing it thoroughly. They could imagine that while these tests were going on, the Directors were expecting every day — certainly at every Board meeting—that there would be a further advance, but a great many unforeseen things occurred in electrical matters. They had hoped to meet the shareholders and to give them all this information some months ago, but their desire had been not to tell them an incomplete story. About May last, when Dr. Fleming was fully engaged on the tests referred to, their manager announced to the Board—with, as he (the Chairman) thought, no preliminary observations—his desire to resign. He (the Chairman), however, asked for a reason, when Mr. Watson threw doubts on the whole concern; but, in order not to put them to any trouble, he expressed his willingness to carry on what business he might be asked to do for the Company pending the appointment of another officer. Of course he had desired to know the reason why Mr. Watson wanted to resign; and the latter produced a letter from his father, who was one of the largest shareholders outside the American Company. He believed it was under the influence of the father that the son wished to resign; but however that might be, Mr. Watson expressed his desire to leave them. That was the position of matters when some letters arrived, which there was some delay in replying to, though this had not been intentional. These letters were pretty closely followed up by notices to shareholders, asking them to meet Mr. Pooley at his chambers. The invitation was not sent to him (the Chairman), or, at all events, he received no invitation, and he believed his colleagues would say that they received no invitation to attend the meeting in question. A friend of his, Colonel Bird, was present at it, and told him what took place—that there was, generally speaking, a feeling of dissatisfaction at the management, and Colonel Bird suggested that the Directors should be approached; but this was not listened to. After this meeting a circular was issued to the shareholders, asking them to approve the petition for winding up. The Directors naturally opposed the petition, feeling that, however desirable liquidation might be, it was a matter to be decided by the general body of the shareholders; and their solicitor sent out a circular to the shareholders, asking those other than the petitioners whether they approved such course of action, or if they preferred to sign the following statement: "I, being a shareholder in this Company, support the opposition of the petition to wind up the said Company, and desire the same to be dismissed." The result was that every shareholder was with the Directors, and, that being the case, it would not require any words from him to point out how lamentable it would be if the petitioners persevered with their action. Theirs was a Company which was simply an introductory company to a big thing; it had only been intended by them, with their capital, to prepare a new thing of great promise, to perfect its details, and then to offer it to some large combination of capitalists. Among the people whose views they asked for were the American Company, who had sent the Directors their proxy, and had expressed their wish that the petition should be opposed. When it came before the Judge, his lordship expressed the opinion as reported in the newspapers—this was what it came to—that clearly no one could pretend that the substratum of the Company was gone. With reference to their future, he (the Chairman) thought there was little doubt that when they had got the battery already alluded to perfect—which he believed they would not fail to do—the business would be a practical one. As to perfecting the battery, he would read them a letter, dated October 8th, which he had received from Dr. Fleming:—

"In reply to your request for a brief statement as to the present condition of the tests I am making with the small battery for the electric ammunition, I may say that I am continuing to test samples of the battery furnished by the inventor. He has not yet entirely satisfied the conditions as to durability and permanence which I have insisted upon as essential before I can inform your Board that his battery will meet all your requirements; but he has produced samples which give a number of discharges amply sufficient for the practical necessities of small arms electric ammunition. Although the inventor has yet to overcome some difficulties in the construction of the battery, it seems to me that he is on the way towards a satisfactory solution of them, and I think it would be a pity to arrest the work at this stage. The question really at issue is the permanence of the battery, and hence these tests necessarily take some months; but I think that the results to be obtained, provided these time-tests can be endured, make it desirable not to terminate them when success is still possible."

Continuing, the CHAIRMAN said that what the Directors really asked the shareholders to do was to have a little confidence in the Board, who were working to the best of their ability, and they proposed that those gentlemen who had not paid up their calls should do so. They desired that Dr. Fleming might have the time given him which he required for the tests he was making. They proposed, in any case, to call the shareholders together again, in about three months, to tell them how they then stood, and not to make any other call without consulting the shareholders. He hoped that he would be able to prevail on those who had presented the petition to withdraw it; otherwise, the Directors would persevere with their opposition, and ask that it might be dismissed. The expenses in the next two or three months would be about £200 or £300. He concluded by proposing the adoption of the report.

Colonel ERNEST VILLIERS, in seconding the motion, observed that the Directors entirely concurred in all that the Chairman had said. In the shareholders' interest he thought it was distinctly advisable that the experiments now going on should be proceeded with, and that the seed they had sown in the past months should not be thrown away until they were quite certain that it would not lead to anything.

Mr. UNDERDOWN, Q.C., said it seemed to him that there were two questions to consider—to receive the report or not. If they did not receive it they would then proceed to propose that the Company be wound up in some way; but he saw no necessity for a compulsory winding up.

Mr. WATSON, sen., assured the Directors that in any proceedings which he and the gentlemen with whom he had been acting had taken, there had been not the least idea of being discourteous to the Board. Their calls were due by a certain date, and unless they had taken some action, they would have had to pay them. The Directors in their report said, respecting the competition at Bisley, that it "attracted many of the most famous rifleshots of the country, and was completely successful." His own information might not be as good as the Directors', but it was in consequence of what he had heard had occurred at Bisley that induced him to write to his son the letter to which the Chairman had referred. The Directors had been so kind to his son that he thought they might feel even influenced to go on with the Syndicate's system longer than they otherwise might, and he therefore urged his son to resign. What he had heard concerning the meeting at Bisley, which wrecked his confidence in the eventual success of the system, was practically this,—the Company allowed so many shots to be fired at their stand for a certain payment, and gentlemen took a rifle and fired. His information was that although they had a right to fire seven shots for their payment, it was exceedingly rare that any man got seven shots that went off out of the gun before he had had a number of miss-fires, and that they were very numerous.

Mr. UNDERDOWN pointed out that the Directors further on in the report alluded to this defect.

The CHAIRMAN maintained that there was no doubt whatever that the competition was sucessful, but they had distinctly drawn attention to the defect which was developed. This, however, had been seen to be in the mechanical construction of the battery cases, not in the principle of the battery.

Major FLOOD PAGE agreed with Mr. Underdown that the important point for their consideration on that occasion was whether the Company was to continue.

Mr. UNDERDOWN thought that the best course for the shareholders to take was to go on with the experiments, and at all events to keep out of the Courts. He was a lawyer himself, but that was his advice to them.

The CHAIRMAN said that, with the permission of the meeting, he would vary the resolution he had proposed in accordance with Mr. Underdown's suggestion; and the motion would then be:—

"That the report and accounts be received and adopted, and the business of the Syndicate be continued."

Colonel VILLIERS said he would second the resolution as amended.

Mr. WATSON, sen., said he had no desire to occupy the time of the meeting, and his purpose in speaking had been to see if they could come to an agreement.

The CHAIRMAN asked Mr. Watson the name of the informant from whom he had received such adverse statements respecting the Syndicate's system.

Mr. WATSON: A gentleman in Belgium—a personal friend.

The CHAIRMAN: No one connected with the Company?

Mr. WATSON: No.

The CHAIRMAN: Had he been to Bisley?

Mr. WATSON: I do not think he had. Continuing, the speaker said he had been much struck with the information he had received about the miss-fires, for he had not put his money into the concern without seeing the experiments, and he himself had seen no miss-fires. The fact, however, was that the laboratory experiments and the shooting at Bisley were carried out under different conditions.

Captain PIXLEY observed that he had fired many shots at Bisley, and he did not have a single miss-fire.

Mr. ACCLES expressed his conviction, from his own experience, that

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the system would not answer. With the best battery in the world he did not see how they were to get a contact; and the great thing was the contact.

Mr. POOLEY read a letter from a firm of gunmakers, who intimated their opinion that the invention could only be used for toy purposes. He proposed an amendment to the effect that the report of the accounts be not adopted, and that the petition before the Court be persevered with. Even if they had a perfect battery now they had not, he said, sufficient money in hand and uncalled to do any good with the invention.

Mr. ACCLES seconded the amendment.

Major FLOOD PAGE hoped the amendment would not be proceeded with. The object for which the Company had been established, as stated in the first article of the Memorandum of Association, was to enter into and carry into effect, with such modifications, if any, as may be agreed upon, the agreement with the American Electric Arms and Ammunition Company, and to purchase or otherwise acquire any other inventions and patents. Although their Syndicate came under the action of the Limited Liability Acts, they were not a trading company. If it was a trading company and had done no business, it might be reasonable to wind up; but the object of the Syndicate was to form another company, and to develope its electrical patents as far as they could. It was within the knowledge of some of those present that he had to do with electrical patents, and he considered that instead of having been a long time, they had been very prudent and careful, and it would be an act of lunacy on their part to wind up the Company. Mr. Accles had remarked that their money was lost, and it certainly was lost if they wound up. If, too, that proceeding were taken, the first thing the liquidator would do would be to make them pay something for the winding up expenses. He was himself in frequent communication with Dr. Fleming, and he believed it was well within the range of probability that they might be successful. Against what had been said by Mr. Accles they must set the practical experience of Mr. Pixley. If they succeeded there would be an immense field for them. They might succeed if they went on, but they could not succeed if they wound up. They had paid seven-tenths of what they would have to pay, and he objected to losing his money by the winding-up of the Company, especially as the Chairman had informed the meeting that no call would be made without their being called together again. The nature of all syndicates was speculative, and the shareholders had speculated in the present case in the hope that by careful experiments they would be able to get a solution of the question affecting the invention in which they were interested. If they did not they must wind up; but if they did they could hand the concern over to another Company, when they might hope to obtain cent. per cent. for their money.

The SOLICITOR, in reply to Major Flood Page, stated that under the Memorandum and Articles of Association of the Company, Table A was adopted except in certain points. Table A was adopted with respect to voting, and by Table A, section 47, no member was entitled to vote at any general meeting unless he had paid his calls. The petitioners had not paid their calls.

The CHAIRMAN stated that it was thus out of the power of the Chairman or the Directors to accept the votes of those who had opposed them who had not paid their calls. He had certainly not anticipated this, and their opponents appeared to have got into a trap of their own setting. The sense of the meeting was clearly in favour of the Syndicate's going on. No doubt they had a difficult task, but it was ten times more difficult when they started. He thought that the Belgian gentleman referred to by Mr. Watson must have received his information from the latter's son. The Directors knew that there had been some miss-fires, but their late manager had not informed them that they had been as numerous as had been stated. He would appeal to the gentlemen who had brought forward the amendment to withdraw it, as they could not vote; and he suggested that the resolution should be passed.

Mr. POOLEY declined to withdraw the amendment; and

The CHAIRMAN stated that he should receive under protest the votes of those who were not entitled to vote. He then put the amendment, and declared it lost on the show of hands, four shareholders voting in favour of it, and the votes of three being received under protest. The resolution was afterwards put and declared carried.

Colonel VILLIERS then proposed the re-election of Major Waller, remarking that that gentleman had given them great assistance. His electrical knowledge was very considerable, and his knowledge of gentlemen who were likely to be of assistance to the Company was also very great.

Colonel the Hon. G. VILLIERS seconded the motion, which was agreed to.

After the Auditors had been re-appointed, the proceedings closed in the usual manner.

In the Court of Queen's Bench on Wednesday, before Mr. Justice Jeune, the hearing of the petition was ordered to stand over for a week, there not having been time for the Company's counsel to read some affidavits which had been sworn on the other side.

International Okonite Company (Limited).

The first annual general meeting of this Company was held on Wednesday last, the 14th of October, at the Cannon-street Hotel, having been adjourned from October 9th.

Mr. SAMUEL POPE, Q.C., presided, and in opening the proceedings said: Gentlemen, in the absence of the Chairman, Lord Greville, whose doctor will not allow him to travel, he being in Ireland suffering from an attack of gout, it has fallen to my duty as Deputy Chairman to take his place, and I therefore call upon the Secretary to read the notice calling the meeting.

Mr. R. COOPER (the Secretary) then read the notice.

The CHAIRMAN said that the shareholders had the reports and accounts before them, and he presumed that they would take them as read, and in moving their adoption it would be his duty to offer just a few remarks. He did not think that they would be many, because the report which he had no doubt they had all read, and which they had just agreed to take as read, was so very full. The fact that the Directors were unable to recommend the shareholders to declare a further dividend on the ordinary shares of the Company was not so satisfactory a one as they could desire it to be; but they must bear in mind, even with this disadvantage, that the amount that had already been paid upon the ordinary stock represented 5 per cent. upon their investment. The idea of the Directors had been that it was more desirable to maintain the prosperity of the Company than to further the desire of individual shareholders for the declaration of a further dividend; and while they looked forward to very great success for the Company they deemed it better not to declare a further dividend in anticipation, but rather to be quite legal in what they did, and to see that the amount distributed was only the amount actually earned, because, although it would have no doubt increased the value of the shares, it would not have been to the true interests of the Company; and the unanimous opinion of the Board was that the Company ought to be managed without "dodging" the accounts and without paying any dividend beyond the actual result of the year's trading; and in the accounts they did propose a dividend which was the actual result of their trading, and which could be fairly and honestly placed before the shareholders. In the period that was embraced in the accounts now under review, the shareholders must bear in mind the special circumstances which attached to it. In the first place, they would remember that they purchased the profits which had accrued from the 1st January to the 13th June, 1890, which amounted to £21,711, which of course not being profit earned by the Company since its constitution, was not a sum that could be legally distributed amongst the shareholders as dividend, and the Directors therefore recommended that as they could not pay a dividend out of it, and as it really was profit made in the past year, it should be used, so to speak, in the reduction of the purchase money, and so as to diminish the ultimate capital expenditure of the Company. In the accounts which were presented, the American accounts were only made up to the 31st of May, 1891, but the English accounts covered a period ending the 30th June, 1891, and the reason of that was that it had been arranged as desirable that the American stock-taking should be to a period a month earlier than the English. Had the American accounts also been carried up to the end of June, they would have had a much larger sum as profit available in the present accounts, indeed the profits would have been increased to the extent of some thousands of pounds that would have enabled them to declare a dividend to the ordinary shareholders beyond what they had already received. They must also bear in mind this, that in common with all industrial undertakings, especially in America, the last nine months, or rather the nine months between September, 1890, and June, 1891, was a time of exceptional difficulty, and they knew that the finances of America, as far as industrial undertakings were concerned, had been very bad indeed. He wished to be allowed to offer an explanation in regard to the following paragraph in the report of the Directors:- "Up to the end of the year 1890 the business was progressive and satisfactory, and the interim dividend then declared was justified by the business done. Since that time the Company had suffered from the results of the severe crisis which took place in the United States in all electrical, engineering, and kindred industries, and which culminated in the failure of the Westinghouse Company." It was the desire of the Board that they should state nothing wrong in their report, and they felt that the word "failure" in this case was too strong a term, as, with outside help, the Westinghouse Company had been reorganised, and the new Company, it was hoped, would become a prosperous concern in the future. Bearing in mind, then, this state of things in the nine months, he thought that they might be very hopeful, having regard to the better condition of things and that their works were fully employed in the manufacture of their specialty, okonite wire. Since the accounts were made up there had been a considerable increase in the business, and there was every evidence that the business itself was healthy and profitable, and when he met the shareholders again (if nothing unforeseen took place) he believed and trusted that, now that a reaction was taking place, they would be able to lay before them a very much more satisfactory statement than they did at present. Their Manchester business had been very much curtailed by their having had to institute a number of alterations, and to introduce new machinery in order to properly carry out the manufacture of their okonite specialty. These were now completed, and the business was in first-rate working order, and they had the assurance of their manager there (Mr Shaw) that there was a prospect of a very healthy English business, and that they were very glad to hear, because they believed that it would not be subject to such fluctuations as was the case on the other side of the Atlantic. As he had already said, the policy of the Board was unanimously to take the shareholders into their confidence, and to deal fairly and honestly by them, and not to have any "dodging" in the management of the Company. He really did not know that he had much more to add; but, as the Chairman of that meeting, he might say that the most cordial co-operation prevailed not only amongst the members of the Board in England, but between the members of the Board of the American Committee of Management, who were themselves Directors. He must express the hope, which was their unanimous hope, that they would have as valuable a business in Manchester as had proved to be the case in America; and they would, he hoped, be enabled to present to the public such a class of manufacture as would make them one of the most successful and one of the best manufacturers of insulated wire. He would be happy to answer any questions that any of the shareholders desired to ask, and he concluded by moving the adoption of the report.

Sir ALEXANDER ARMSTRONG, K.C.B., F.R.S., seconded the motion.

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The CHAIRMAN invited discussion.

Mr. FRANK SQUIRES said that he thought that although the Chairman had given a very fair explanation of the reason of their not paying a dividend on the ordinary shares, that there had been a large outlay at Manchester for machinery, which, he presumed, was to replace obsolete machinery. He wished to know the amount at which their goodwill stood, and in regard to the non-payment of any further dividend upon the ordinary shares, he would like to know whether the legal gentleman who looked into the matters before the formation of the Company was aware that this sum of £21,711, which they purchased as profit made between January and June, 1890, was an amount which could not be legally divided amongst the shareholders. He thought it ought to have been stated in the prospectus, because the statement that they had made that amount of profit had induced him to take shares. He thought the prospectus led them to believe that this amount of money was available for distribution among the shareholders, and he wanted to know whether their legal adviser was aware that it was not.

The CHAIRMAN: Of course he was.

Mr. SQUIRES said he would like an answer to that question, and also as to the machinery at Manchester, which appeared to be obsolete, and had had to be replaced by new plant when they made their alterations.

The CHAIRMAN: Not at all, not at all. I did not say obsolete. It had been shifted in the works. The new plant is the plant for our specialty, our okonite wire.

Replying to further remarks, the CHAIRMAN stated that there was not a single machine which they had purchased but what was fully at work, and doing good work, and most of the machinery was the very best of its class for the production of insulated wire.

Mr. SHAW, the Manager of the Manchester Branch, corroborated the remarks of the Chairman.

Mr. SQUIRES expressed himself satisfied with the explanation, but said that he would like to have an explanation of whether their lawyers were aware that the £21,000 would not be distributed as dividend.

The CHAIRMAN: That is a fair question.

Mr. PETERS said that he much approved of the view which had been expressed by the Chairman of the desire of the Directors to give a fair, clear, and straightforward statement of everything to the shareholders; and he therefore wondered why they had not, as was the case in many Companies, given a trading account. He thought, having regard to the large capital of the Company, £400,000, that the shareholders were entitled to a trading account, in order that they might see how the profits of the Company were made up. He wanted also to be informed how much of the large sum of £218,000 was really represented by *bonâ fide* goodwill. When the Directors declared the interim dividend on the ordinary shares up to December, 1890, which took £10,000, he naturally assumed that they had a large amount still left before they would have ventured to do so, and he thought therefore that they could have made during the second six months hardly any profit at all.

The CHAIRMAN said he thought that in the original prospectus some announcement was made to the £21,000 not being divisible, but he had been looking through it and could not find it.

A SHAREHOLDER asked when there was the likelihood of giving a quotation of the Company's shares upon the Stock Exchange.

The CHAIRMAN: We have a quotation.

The SHAREHOLDER: I have not seen it.

The CHAIRMAN: That is because no one wants to sell, we have had it a good many months.

A SHAREHOLDER: Perhaps Mr. Stevens, the Managing Director, could give us some information, without reflecting on you.

The CHAIRMAN: Upon what point?

The SHAREHOLDER: About the Company generally.

The CHAIRMAN: No doubt, and he shall have an opportunity, but I am quite familiar.

A SHAREHOLDER: It does not reflect upon you at all.

The CHAIRMAN, replying to the remarks that had been made, said that as to the question of providing a trading account, the Directors did not think that such a course would be desirable, because if they made these statements public it would let their competitors and their customers know what they were doing, and they would endeavour no doubt to cut down their profits. There were many industrial undertakings, Armstrongs, for instance, which did not publish a trading account; but he might say at once that if any shareholder desired any information upon any point, and would call at the office, the Managing Director would be happy to give that information if it was not detrimental to the interests of the Company. As regarded the question raised by Mr. Squires as to the matter of what they might call the indivisible profit of £21,000, that was a thing which, of course, every lawyer knew they could never divide profit which had not arisen from trading. The purchase of 21,000 sovereigns for £21,000 was not a profitable transaction, but as far as it went it was satisfactory. The reason that it was such a large sum had arisen in the following way. It was originally fixed that the American Company should be taken over at January 1, 1890; but owing to circumstances on which he need not enter now, there was a considerable delay in regard to the registration of the Company, and although the date of their being entitled to profits was from the adoption of the contract, they stood to take the profits from January 1st, although the registration was not completed till about the month of June.

Several other shareholders expressed the view that it should have been clearly stated in the prospectus that they were not entitled to have this sum of money divided amongst them.

Mr. SMITH said that he thought that the greater part of the shareholders entertained the view that this money would be divided.

The CHAIRMAN said that he felt with shareholders who had entertained that view, but they must exercise the Englishman's privilege and grumble, and he feared, speaking as a lawyer, that it must end with the grumble; because they could not pay the dividend, however much they would like to do so.

Mr. SQUIRES said did their legal adviser know this at the time?

The CHAIRMAN said that of course he knew it.

Mr. SQUIRES thought that it ought to have been mentioned in the prospectus.

The CHAIRMAN said that he had no doubt that a statement like that in a prospectus would lead the lay mind to believe that that profit was divisible. After all, the shareholders had the advantage, for, although these £21,000 did not go into their pockets, they had them in the accounts, because they would be utilised for the purpose of reducing the amount that they had paid for their property, instead of that sum having to come out of the money available for dividend in the future.

A SHAREHOLDER: It would have been very much better if it had been put in the prospectus that the money was not divisible. It would have been more satisfactory to us. I became a shareholder because I thought that this £21,000 would be divided, and that it was a sort of nest egg.

The CHAIRMAN said that with all respect to the shareholder who had just spoken, if that gentleman bought his shares on the idea that they would declare a dividend out of that £21,000, and then wanted to sell his shares at the improved price which such a declaration would bring about, then he (the Chairman) wished to say that such shareholders were most undesirable in an industrial company, and their desires ought not to be encouraged.

The SHAREHOLDER repudiated having any such idea.

The CHAIRMAN said that, with regard to the question of the trading account, he had already answered it—it would be undesirable. As to the item of £218,000, the matter was fully set out in the prospectus, and the value of the real estate given, so that by a simple calculation they could arrive at the amount of the goodwill; but roughly it might be taken that out of the £218,000, £90,000 represented the value of goodwill, processes, patents, &c., and other matters of that kind in England and America.

A SHAREHOLDER: I should like to know when the Manchester business is likely to be in full working order.

The CHAIRMAN: It is now at the present time. It is in full working order; and Mr. Shaw, the manager, tells us that the okonite samples are now before the customers, and he expects orders almost immediately.

A SHAREHOLDER asked: How long the new works at Manchester had been going?

Mr. SHAW: Within the past 14 days.

The SHAREHOLDER: We shall have nine months trading this year at Manchester?

The CHAIRMAN: Yes.

A SHAREHOLDER: Have you many orders on hand?

The CHAIRMAN: Oh, yes, a considerable increase over any previous record of the Company.

Another SHAREHOLDER said that at the statutory meeting the question was raised as to whether this Company's process was likely to be adopted by any of the large electric cable companies; and he wanted to know whether the Chairman could give them any further information upon that point that day.

The CHAIRMAN said they were endeavouring to get their okonite wire adopted in every possible direction, but he believed as yet that the opinion of electricians was that gutta-percha was the best insulating medium for submarine cables, and he did not know whether or not they would be able to disabuse the minds of electricians of that prejudice.

The report was then adopted.

The CHAIRMAN said that acting upon the suggestion made by one of the shareholders, that the Managing Director should give his views, and that Mr. Shaw, the manager of their commercial department in Manchester, should give his opinion of their prospects there, he begged to call upon Mr. Stevens to address the meeting.

Mr. ALFRED VAUGHAN-STEVENS said that there was very little indeed that he could add after the able statement which had been made by their Chairman, and he did not desire to go into particular details at all, or to go into any information as to their accounts or the prospects of their business. They were very closely watched, and were in competition with many firms of great standing and considerable wealth, and it would be highly improper to go into questions of details or the amount of their sales in England or America and to give away knowledge to their competitors. There was one thing he would like to say, they were not relying upon any particular branch of their business. Their works at Manchester were solid, sound, and healthy, as Mr. Shaw would be able to tell them later on, and not only were they making their okonite specialty, but every kind of electrical wire. One of the reasons why the large electric lighting companies had not adopted their okonite wire for their large mains and heavy cables—indeed, the chief reason—was that it was very expensive; and they had therefore been manufacturing other kinds of insulated wires, covered with cotton, paper, &c., and insulated with oil. They had also been laying down in their English works special and important machinery for lead covering. They were very cautious in the manufacture of these machines, having the castings made all over the country, and put together in their own workshops. He was pleased to be able to announce that they were now upon the list of contractors to the Admiralty, which was a very important consideration, and they believed that the War Office would also follow. It was a very important matter because, before they could get on the list, their works had to be examined by an inspector sent down for the purpose, and the Government would not allow any firm to contract unless they were sure they were in a solid position to execute any large orders in a short time which might be sent to them. He believed that at the present time there were only three contractors for insulated wire upon the Admiralty List; it was a very "close borough," but they meant to creep in and get their proportion, which he had no doubt they would

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do, and, if they were successful, that of itself would give a very respectable dividend upon their capital. There was also a very large business to be done in regard to the railways. Naturally, the railways were very conservative bodies, and having tested wires and found them satisfactory they did not care about moving until they were perfectly satisfied that they could do better. They had received some small sample orders and had had no complaints; indeed, everything seemed to be very satisfactory, and they had laid down one large installation. He trusted before very long that they would have a large development of business in this direction. This Company possessed, with one exception only, the finest and most complete factory for the manufacture of electric wire in this country, and they were far and away the largest company of the kind in America. Indeed, with one exception, he thought he might call themselves the largest and most powerful insulated wire-making company in the world. He had been over to America twice since they took the Company over, and he had found the business there to be admirably managed. It was managed by people who had taught themselves in a great measure. They were experts in india-rubber, and also experts in electricity, but they did not possess the experience which came from a long handling of a very technical matter such as insulated wire. Mr. Connolly, their works manager, had been connected with the business of insulated wire making for a great many years, and when he first went out there and learnt the technical part of the business thoroughly in regard to the okonite wire, he taught them in return a great many processes of which they were unaware, and which would now be very useful in the business. In concluding his remarks, Mr. Stevens referred with satisfaction to the growth of the sales, and pointed out that had it not been for the severity of the winter, which entirely stopped building operations for many months, they would be in a much more advanced condition in regard to Manchester. At the present time, however, they were in full working order, and the prospects, as Mr. Shaw, their works manager, would tell them, were very satisfactory indeed. He concluded by expressing his willingness to afford any further information that any of the shareholders might desire to ask.

The CHAIRMAN called upon Mr. Shaw to address the meeting.

Mr. SHAW said that he did not know that he could add much to what their Managing Director, Mr. Stevens, had already said, with regard to the management at Manchester. There was one point which he would like to be allowed to touch upon, and which had been alluded to by the Chairman in reply to a shareholder asking for a trading account. He, the speaker, thought it would be most unwise for them to enter into any statements upon matters of detail, because it let the public into the details of their business, and it at once placed a weapon in the hands of his competitors to be used all over the country against him. With regard to the growth of their business, since it became their property it had gone on very well indeed, and the prospects this year were most encouraging. Still, it had to be borne in mind that the past year in the United States and, indeed, elsewhere, had been one of the worst for electrical undertakings since the year 1887. The firm of Mathers and Platt, with whom he was for twelve years as chief estimate clerk, had done in the last year 50 per cent. less business than in the year 1890, in their electrical department, and what was their case was the case of other people. He was pleased, however, to see that there was a revival of a very marked type, and the results so far of their working were most satisfactory. Having, as they had, a specialty in this okonite wire, they would be able to take advantage of this revival, and they would not be affected so much by the competition of other manufacturers, because, if you were manufacturing an article which other people could also manufacture, the competition then became a matter in regard to price; but if you possessed (as they did) a specialty, it was not so much a matter of price as it was a matter of satisfying the consumer that the article you produced was the best which could possibly be got. He was confident that during the next twelve months they would do much better than had been the case during the past year. As Mr. Stevens had told them, the very severe winter had affected their building operations at Manchester, but now all that was over and they were in full working order, and they were manufacturing okonite and gutta-percha and all kinds of electrical wire. As had also been mentioned, they had been entered upon the Admiralty list, which was an exceedingly satisfactory matter. The Inspector announced himself as exceedingly satisfied with what he saw on his visit to the works, and he was coming down again at an early date to inspect another branch of their business, and they therefore expected that they would be placed upon another branch of the Government service, and would be able to compete satisfactorily with other large contractors.

The CHAIRMAN said he thought the meeting ought to be very much obliged to the gentleman who had requested that the Managing Director should give some further information than he (the speaker) was able to supply, as occupying the position of Deputy-Chairman of the Company. It was, and it would always remain, the desire of the Directors at the annual general meetings to take the shareholders entirely into their confidence, and to allow them to ask any questions, and to obtain any information that could be given without detriment to the interests of the Company.

A SHAREHOLDER: We are very much obliged to you, Sir.

The CHAIRMAN said that the next resolution that he had to propose was—

"*That this meeting sanctions the recommendation of the Directors as to the declaration of a dividend up to the 30th June, 1891, at the rate of 8 per cent. per annum, less income-tax, on the preference shares, leaving a balance of £259. 7s. 2d. to be written off preliminary expenses.*"

Mr. HUMPAGE seconded the motion, which was carried.

A SHAREHOLDER: When will the dividend be paid?

Mr. STEVENS: We have to make some arrangements with America.

The CHAIRMAN: I should think in a week or ten days. It will be necessary to make some arrangements to pay it simultaneously in America and in England. The only other matter is the reappointment of the auditors, Price, Waterhouse and Co., and I can only say about them that they are very strict. Perhaps some shareholder will propose it, as it comes from that side of the table.

Mr. STEVENS: I can only say they gave me a great deal of trouble.

A SHAREHOLDER: What is the remuneration?

The CHAIRMAN: It is not fixed.

It was then moved, seconded, and approved that Messrs. Price, Waterhouse and Co. should be re-elected as the Auditors of the Company, at a remuneration to be agreed upon between them and the Board.

A vote of thanks to the Chairman terminated the proceedings.

Eastern Extension, Australasia, and China Telegraph Company (Limited).

The following report has been issed by the Directors of this Company for the half-year ended June 30th last, to be submitted to the thirty-sixth ordinary general meeting to be held at Winchester House, London, E.C., on Wednesday next, the 21st inst., at 2 o'clock:—

The gross receipts, including Government subsidies, have amounted during the half-year to June 30th to £264,878. 6s. 11d., against £254,856. 18s. 10d. for the corresponding half-year of 1890. The working expenses, including £17,318. 5s. 11d. for cost of repairs to cables and expenses of ships, absorb £71,476. 15s. 8d., against £76,670. 9s. 3d. for the corresponding period of 1890, leaving a balance of £193,401. 11s. 3d. From this is deducted £2,981. 17s. 1d. for income tax, £33,074. 14s. 5d. for interest on debentures, debenture stock, and contribution to sinking fund, and £2,179. 10s. 2d. for special expenditure as shown in the revenue account, leaving £155,165. 9s. 7d. as the net profit for the half-year.

One quarterly interim dividend of 1½ per cent., amounting to £31,250, has been paid during the half-year, and another of like amount will be distributed on the 15th instant, leaving £92,665. 9s. 7d. to be carried forward.

All the Six per Cent. Debentures that were outstanding when the last report was issued have been paid off and cancelled, and the Stock Exchange have granted an official quotation in the New Four per Cent. Debenture Stock, which now stands in the market at a considerable premium.

It is with deep regret that your Directors have to record the death, on the 12th ultimo, of their much esteemed colleague, Sir Thomas Fairbairn, Bart., who had been associated with the Company from its inception. It is not proposed to fill the vacancy in the directorate thus occasioned. As, however, Sir Thomas Fairbairn was also one of the trustees for the Five per Cent. Australian Subsidy Debenture Holders, it has been deemed advisable to appoint a new trustee, and Mr. John Denison Pender has undertaken to act in this capacity.

The guarantee arrangement made with certain of the Australasian colonies for testing the effect of a 4s. rate to Australia came into operation on May 1st last, and the increase of traffic resulting from the reduction of tariff is so far encouraging. As, however, the accounts embrace only two months' receipts at the reduced tariff it is too early to form any reliable opinion as to the result of this important experiment.

In accordance with the arrangements entered into with the Indian Government the Company's station at Elephant Point (Rangoon) has been closed, and a considerable portion of the cable between Elephant Point and Penang picked up and utilised elsewhere.

An arrangement has been concluded with the Dutch Government for connecting by submarine cable Sumatra with Penang, so as to bring the Netherlands Indian Government telegraphs into direct communication with the Company's system at Penang. The cable for this purpose will be taken from the Company's depot at Singapore, and laid in the course of the next few months.

Brazilian Submarine Telegraph Company (Limited).

The following is the report of the Directors of this Company for the half-year ended 30th June last, to be submitted to the thirty-sixth ordinary general meeting of shareholders on Wednesday next, the 21st inst., at 12 o'clock:—

The revenue for this period amounted to £158,905. 3s. 1d., and the working expenses to £25,449. 5s. 0. This very exceptionally increased revenue mainly arises from the disturbed state of affairs in South America. After providing £12,880 for debenture interest and sinking fund, and £2,320. 2s. 9d. for income tax, there remains a balance of £118,255. 15s. 4d.; to this is added the sum of £11,121. 4s. 0d. received in respect of traffic receipts between March, 1889, and December, 1890, hitherto under dispute, and £23,833. 17s. 5d. brought forward from 31st December last, making a total of £153,210. 16s. 9d. A quarterly interim dividend amounting to £32,500 has been paid, and £60,000 transferred to the reserve fund, increasing that fund to £474,878. 7s. 0d.

The Directors now recommend the declaration of a final dividend of 1s. per share, making with the interim dividends a total dividend of 6 per cent. for the year, and also the payment of a bonus of 4s. per share, both free of income tax, which together will amount to £32,500, leaving a balance of £28,210. 16s. 9d. to be carried forward. The dividend and bonus will be payable on the 22nd instant.

On the 31st July last the sum of £16,000 was transferred to pay off the 160 bonds of the 1884 issue, drawn for redemption in April last. This repayment reduces the debenture debt to £128,200.

The receipts for the half-year include the sum of £1,500 dividend to 31st December, 1890, on the Company's shares in the African Direct Telegraph Company, Limited.

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An interruption occurred on the 11th August last in the 1874 cable of the St. Vincent-Pernambuco section, about 50 miles from the coast of Brazil. By arrangement with the Eastern Telegraph Company that Company's s.s. "Mirror" was sent out, and a repair effected on the 17th September. A fault was also cut out of the same cable, the tests of which are now highly satisfactory.

The Directors have made arrangements for applying the Duplex system of working to the three sections of the No. 2 cable, whereby its power of transmission will be greatly increased.

The various sections of the Company's line are in good working order.

The Hon. W. St. John F. Brodrick, M.P., and Lord Sackville A. Cecil retire by rotation at this meeting, and being eligible for re election as Directors offer themselves accordingly. The auditors, Mr. Henry Dever and Mr. John Gane, also offer themselves for re-election.

NEW COMPANIES, STATUTORY RETURNS, &c.

BRITISH ELECTRIC INSTALLATION CONTRACTORS (LIMITED).—This Company was registered on October 12, 1891, with a capital of £20,000, in £5 shares, by Messrs. Waterlow Brothers and Layton (Limited), Birchin-lane, E.C. The objects are:—To carry on, in the United Kingdom, the business of an Electric Lighting Company in all its branches, and to undertake the lighting of streets and buildings (both public and private); to produce and supply electricity for light, heat, motive power, and other purposes; to manufacture and deal in engines, machinery, wires, lamps, instruments, and apparatus necessary for the production, storage, supply, measurement, and application of electricity, or electrical energy. The subscribers are (with one share each), J. Millington, J. Duce, A. H. Parker, W. H. Walter, S. T. Castle, H. Webb, and H. A. Leicester, all of Worcester. The number of Directors is not to be less than three nor more than seven, the first to be appointed by the subscribers. Qualification, £125; remuneration to be fixed by the Company.

PERFECTA STEEL TUBE COMPANY (LIMITED).—This Company was registered on the 12th October, 1891, with a capital of £30,000 in £10 shares, by Beale and Co., 28, Great George-street, Westminster, S.W. The objects are:—To carry on the business of manufacturers of weldless steel tubes for locomotive, marine, and other boilers, shafting, projectile, torpedoes, &c. The number of Directors is not to be less than three nor more than five, the first being W. Pearce, H. Lea, P. A. Hopkins, and R. C. Hopkins, all of Birmingham.

RAILWAY AND WORKS CONTRACTORS (LIMITED).—This Company was registered on October 6, 1891, with a capital of £102,620, in £10 and £1 shares, by Messrs. Norton, Rose, Norton, and Co., 57½, Old Broad-street, E.C. The objects are:—To undertake in any part of the world the construction, maintenance, equipment, or working of any railway, tramway, dock, harbour, water or gas works, system of electrical lighting, chemical works, &c.

READ, CAMPBELL AND COMPANY (LIMITED).—This Company was registered on October 8, 1891, with a capital of £150,000, in £10 shares, by Messrs. Budd, Johnsons, and Jecks, 24, Austin Friars, E.C. The objects are:—To take over the business of engineers and contractors for public works, carried on by Messrs. Read and Campbell at Broad-street-avenue, E.C., and to contract, carry out, develop, and control railways, tramways, electric light, telephonic, telegraphic and power supply works, &c. The first Directors are Messrs. H. V. Rudston Read, A. Johnstone Campbell, and G. St. John Mildmay.

VULCAN ENGINE COMPANY (LIMITED).—This Company was registered on October 12, 1891, with a capital of £3,000 in £1 shares, to carry on the business of engineers, contractors, brass, iron, and metal founders, gas engine manufacturers, electricians, electric light contractors, dynamo manufacturers, manufacturing chemists, &c. Edward W. Field, of 52, Bedford-road, Reading, is the first Managing Director, with a remuneration of £12 per month. Registered by George Tilling, Devonshire-chambers, Bishopsgate-street, E.C.

ELECTRIC INSTALLATION AND MAINTENANCE COMPANY (LIMITED).—An agreement (filed on October 6, 1891), made August 13, 1891, between J. E. H. Gordon and Company (called the contractors) and the above Company, states that whereas this Company have arranged with the Crystal Palace Company (Limited) for the supply of electric light by means of electric motors to exhibitors and others at the forthcoming Exhibition, and whereas this Company have obtained a Provisional Order (August 14, 1891) relating to the electric lighting of the Crystal Palace and District; and whereas this Company have entered into an agreement with R. C. Adams Beck for the acquisition of certain premises known as the Springfield Brewery, Wells-road, Sydenham, intended for a central station; and whereas the contractors are willing to contract for the execution of certain works for £51,175, it is agreed that works comprising a central station, with buildings, chimney, foundations, boilers, engines, dynamos, switchboard instruments, &c., capable of supplying current for 20,000 8 c.p. lamps connected, or for working 400 break horse-power in the Crystal Palace; a main to be run from the central station to the transformer room in the Crystal Palace, capable of carrying the whole of the current which the Company can generate, the main to consist of five positive and five negative cables; a complete set of motor dynamos, for transforming the current from 1,000 volts to 100 volts, are to be executed by the contractors, ready to supply electricity as may be required on the 1st January next. A penalty of £10 is to be enforced for each day after time. The payments for the above to be as follows:—£2,500 within a week of the allotment of the shares recently issued by the Company; £2,000 on the 5th October; £2,000 on the 5th December; £4,717. 10s. on the 5th February, 1892; £2,500 on the 5th March, 1892; £4,717. 10s. on the 5th April, 1892; £1,500 on the 5th August, 1892; £20,000 at the option of the Directors; and the balance (£11,240) to be satisfied by the allotment of 1,124 fully paid £10 shares. An agreement, dated the 13th September (filed 6th October), between the same parties, directs that the payment of £19,935, instead of as above, shall be as follows:—£2,500 to be paid on the 15th September; £1,666. 13s. 4d. on the 15th October; £1,666. 13s. 4d. on the 15th December; £4,550 16s. 8d. on the 15th February, 1892; a similar sum on the 15th April, 1892; and the remainder (£5,000) by the allotment of 500 fully paid £10 shares. Office: 4, Great Winchester-street, E.C.

ELECTRIC WELDING COMPANY (LIMITED).—An agreement made 20th August, 1891 (filed October 6th), between the City of London Contract Corporation (Limited), the vendors, and the above Company ("the English Company"), states that whereas the vendors have agreed to purchase from the Thomson European Electric Welding Company of Boston, U.S.A. (the Thomson European Company), certain letters patent, Nos. 10,241 of 1886, 9,686 of 1888, 361 of 1889, 377 of 1889, 8,038 of 1889, 14,880 of 1889, 20,962 of 1889, and 4,657 of 1890; and from the Thomson Electric Welding Company, also of Boston, U.S.A., certain letters patent, Nos. 9,300 of 1889, 8,229 of 1890, 8,242 of 1890, 18,625 of 1890, and 20,510 of 1890; and have also purchased certain machinery from the above companies, it is agreed that the vendors shall sell, and the English company shall buy, the above-mentioned patents and machinery, and in full satisfaction thereof £128,670 in cash and £83,330 by the allotment of 8,333 fully paid shares, numbered 1,001 to 9,333, to the vendors or their nominees. An agreement between the Thomson Electric Welding Company, of Boston, U.S.A., and the above Company, undated, has also been filed. The statutory return of this Company, *made up to August 4, 1890*, was filed on October 8, 1891. The Company, which was registered on May 1, 1890, has a capital of £460,000 in £10 shares, seven shares had been taken up at the time of the return, the original subscribers being the only members of the Company. No payments have (according to the return referred to) as yet been made. Office: 2, Tokenhouse-buildings, E.C.

ELECTRICAL SUPPLIES AND FITTINGS COMPANY (LIMITED).—The registered office of the above-named Company has been removed from 15, St. Helen's-place, Bishopsgate-street, E.C., to Faraday House, Charing Cross-road, London, W.C. This Company was registered on October 31, 1890, with a capital of £20,000, divided into 3,800 ordinary and 200 founders' shares of £5 each. At the date of the statutory return, March 17, 1891, 127 ordinary and 76 founders' shares were taken up, 30s. per share called up on the ordinary and the full amount on the founders' shares, and £560 paid, leaving £10. 10s. unpaid.

FREEDMAN BATTERY COMPANY (LIMITED).—The registered office of this Company has been removed from 276, Strand, London, W.C., to 66, Berners-street, Oxford-street, W. (Filed August 1, 1891.) This Company was registered on Sept. 1, 1890, with a capital of £2,000 in £1 shares.

W. T. HENLEY'S TELEGRAPH WORKS COMPANY (LIMITED).—At an extraordinary general meeting of the above Company, duly convened and held at the Cannon-street Hotel, E.C., on September 1, 1891, the following special resolution was duly passed, and at a subsequent extraordinary general meeting, duly convened and held at the offices, 27, St. Martin's-lane, E.C., on Sept. 18, 1891, confirmed:—That the capital of the Company be increased to the sum of £100,000 by the creation of 3,000 new Seven per Cent. Preference Shares of £10 each. (Filed on October 1, 1891.)

INSTITUTE OF MEDICAL ELECTRICITY (LIMITED).—At an extraordinary general meeting of the above Company, duly convened and held at the registered office of the Company, 35, Fitzroy-square, London, W., on September 15, 1891, the following resolution was passed; and, at a subsequent extraordinary general meeting of the said Company, also duly convened and held at the same place, on October 1, 1891, duly confirmed:—"That the Institute of Medical Electricity be wound up voluntarily, and that John Walter Biggs, of 12, Delahay-street, Westminster, be appointed liquidator to conduct such winding-up." (Filed October 10, 1891.) The above Company was registered on February 11, 1888, with a capital of £20,000, in £1 shares, to carry on the business of "The Electrified Rooms Company (Limited)." The first Directors were:—Dr. Wm. Lant Carpenter, H. E. Upton, Major-General E. A. Berger, and H. Newman Lawrence. At the date of the last return, February 17, 1891. 5,362 shares were taken up, 2,025 of which were fully paid. Upon 2,077 of the remainder the full amount was called, and 12s. per share was called upon the rest. £2,833 was paid, leaving £98. 15s. unpaid.

NATIONAL ELECTRIC SUPPLY COMPANY (LIMITED).—The registered office of this Company has been removed from 12, Coleman-street, London, E.C., to Victoria-buildings, Preston (filed on October 9, 1891). This Company was registered on October 28, 1889, with a capital of £100,000, in £5 shares, but no annual return has as yet been filed. The statutory return, filed March 14, 1890, shows that 98 founders' and 490 ordinary shares have been taken up, £1 per share called on the ordinary, and the full amount on the founders' share, and £970 paid, leaving £70 unpaid.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended October 9th were £4,901.

CITY AND SOUTH LONDON RAILWAY COMPANY.—The traffic receipts of this Company for the week ended October 11th amounted to £747; aggregate receipts for half-year to date, £10,410.

DIRECT UNITED STATES CABLE COMPANY (LIMITED).—The Board have resolved upon the payment of an interim dividend of 3s. 6d. per share, free of income-tax, being at the rate of 3½ per cent. per annum, for

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the quarter ended September 30, 1891; such dividend to be payable on and after the 24th inst.

MIDDLESBOROUGH (KENTUCKY) ELECTRIC LIGHT COMPANY.—At a meeting on Monday last, at Winchester House, of the English shareholders of the Middlesborough Town Company, which may be termed the parent Company of the Middlesborough Electric Light Company, it was announced by the Chairman that the whole of the companies affiliated to the Town Company were to be reconstructed, and that it was proposed that Mr. Powers, at present a Director of the Town Company, would accept the presidency and managing directorship of the Electric Light Company. The reconstruction is necessary, owing, it is alleged, to the excessive expenditure of the American directorate. The new Company will be reconstructed on English models, and the English shareholders will have the control of their own property.

ST. JAMES'S AND PALL MALL ELECTRIC LIGHT COMPANY (LIMITED). The electric current sold for the quarter ended September 30th last amounted to £5,279, as against £1,818 for the corresponding period of last year.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended October 9th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,797.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Oct. 7.	Price Wednesday, Oct. 14.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Oct. 14. Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
£1,300,980	Stock	12/0	Anglo-American	48¼ 49¼	48½ 49½	5 1 0	Jan., Apr., July, Oct.	49¼	49
£2,849,510	Stock	24/0	Do. Preferred	87½ 88½	87⅞ 88⅞	5 15 10	" "	88	87½
£2,849,510	Stock	5/0	Do. Deferred	12⅝ 13⅛	12⅝ 13⅝	..	..	13⅛	13
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99 102	99 102	3 18 5	January and July	..	..
130,000	£10	5/0	Brazilian Submarine	12 12½	12 12½	6 16 0	Mar., June, Oct., Dec.	12⅝	12
£69,200	£100	5%	Do. 5 per Cent. Bonds	99 102	99 102	4 18 0	January and July	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107	103 107	4 13 6	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	122 124	125 130	5 7 8	April and October	127	125
16,000	10	8/0	Cuba Submarine	10½ 11½	10 11	7 5 6	February and August	..	..
6,000	10	10%	Do. Preference 10%	17 18	17 18	5 11 1	" "	..	..
12,931	5	2/0	Direct Spanish (£4 paid)	3½ 4	3½ 4	7 0 0	April and October	..	..
6,000	5	10%	Do. Preference 10%	9½ 10½	9½ 10½	4 15 3	" "	..	..
60,710	20	3/6	Direct United States	11 11¼	11 11¼	6 4 5	Jan., Apr., July, Oct.	11⅞	10⅞
400,000	10	5/6	Eastern	14¼ 14⅜	14¼ 14⅜	4 9 8	" "	14⅜	14¼
70,000	10	6%	Do. 6 per Cent. Preference	15 15½	15 15½	3 17 5	" "	15½	15¼
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	107 110	107 110	3 12 9	May and November	108⅜	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	107 110	4 10 11	February & August	..	..
250,000	10	2/6	Eastern Extension	14⅞ 15⅛	15 15½	4 12 7	Jan., Apr., July, Oct.	15½	15
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock	106 109	106 109	3 13 5	February & August	108½	..
£85,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	104 107	104 107	4 13 6	January and July	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb. 1900	102 105	102 105	4 15 3	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd)	..	99 102	3 18 5	January and August	..	..
180,227	10	4/6	Globe Telegraph and Trust	9⅜ 10	9⅜ 10	5 7 6	Jan., Apr., July, Oct.	9⅜	9⅜
180,042	10	6%	Do. 6 per Cent. Preference	14⅞ 15½	14⅞ 15½	3 19 4	" "	15⅛	14⅞
150,000	10	5/0	Great Northern	18¾ 19¼	18⅞ 19¼	4 8 4	Jan., April, and July	19⅛	18⅛
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	104 107	105 108	4 12 7	March & September	..	..
17,000	25	37/6	Indo-European	41 43	41 43	5 18 3	May and November	43	42½
38,348	10	5/0	London Platino-Brazilian	6½ 7½	6½ 7½	6 0 0	" "	7½	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105 108	105 108	5 11 1	March & September	..	..
9,000	8	4/0	Reuter's	8 8½	8 8½	4 14 1	April and October	..	..
3,381	£100 Cert.	£1	Submarine Cables Trust 6%	120 125	120 125	4 16 0	" "	..	..
15,609	10	6/0	West African Telegraph	7½ 8½	7½ 8½	5 17 8	January and July	..	..
£281,400	100	5%	Do. 5 per Cent. Debentures	97 100	97 100	5 0 0	March & September	99½	..
30,000	10	2/0	West Coast of America	3⅞ 4⅛	3⅞ 4	..	January and July	..	..
£150,000	100	8%	Do. Debentures 8% 1902	98 103	98 103	7 15 4	June and December	..	..
88,321	10	9d.	West India and Panama	1⅜ 1⅝	1⅛ 1⅜	..	..	1⅜	..
34,563	10	6%	Do. 6 per Cent. 1st Preference	9¼ 9½	8⅝ 9¼	6 9 9	May and November	9½	9
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	8 9	7⅞ 8⅞	7 1 2	" "	..	..
61,683	15	9/0	Western and Brazilian	10⅞ 11½	10⅞ 11½	6 13 4	" "	11⅛	11
30,364	7½	1/6	Do 5 per Cent. Cumulative Preferred	6½ 7	6½ 7	5 7 3	—	7	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	4½ 5	4¼ 4⅜	..	..	4⅛	4⅜
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	102 105	103 106	5 13 2	February & August	105	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	102 105	103 106	5 13 2	" "	104½	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	120 125	120 125	5 12 0	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	98 102	98 102	5 17 8	March & September	..	..
			TELEPHONES.						
224,850	14/0	0/5†	Consolidated Telephone Const. & Maintenance	1⅞ 1⅝	1⅞ 1⅝	..	May and November	½	—
220,000	£1	4·76d.	Oriental (11s. paid)	1⅜ 1⅝	1⅜ 1⅝	6 3 11	Yearly	..	..
438,984	5	3/6	National	4⅜ 4⅝	4½ 4⅝	6 13 4	June and December	4⅛	4⅜
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½ 13	12½ 12⅝	4 14 1	" "	12⅜	12⅜
15,000	10	6%	Do 6 per Cent. Cumulative 2nd Pref (£8 pd)	12 13	12 13	3 14 1	" "	..	..
350,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd)	105 107	105 107	4 4 1	..	106½	106
58,000	5	1/0	United River Plate	2 3	2 3	..	January and July	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85 95	85 95	5 5 8	..	..	..
			ELECTRICITY SUPPLY COMPANIES						
1,000	£10	..	City of London Electric Lighting (£4 paid, £10 Sh.)	4⅛ 4⅜	4⅛ 4⅜	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	.. ..	.. ..	..	..	..	..
5,322	£5	..	House to House Electric	4⅛ 5	4⅛ 5	..	..	..	..
30,000	£5	..	Liverpool Electric Supply (£3 paid)	4⅛ 5⅛	4⅛ 5⅛	..	..	..	..
111,000	5		London Electric Supply	2 2⅛	1⅞ 2⅛	..	..	..	..
48,900	£10	2/0	Metropolitan Electric Supply (fully paid)	10 10⅛	9⅞ 10¼	..	..	10¼	9⅞
6,318	10	..	Notting Hill Electric Lighting (£8 paid)	.. ..	3½ 4½	..	..	..	..
7,730	£5	3/6	St. James' and Pall Mall	8 8½	7¼ 8½	..	..	8½	7⅞
..	..	7%	Do. 7% Preference	6¼ 7¼	7 7½	..	..	7⅞	6⅞
42,853	5	..	Westminster Electric Supply (£5 paid)	5⅛ 6⅛	5⅛ 6⅛	..	..	6⅛	6⅛
			ELECTRIC MANUFACTURING, &c., COMPANIES						
£2,550	10	..	Blackpool Electric Tramway	.. ..	.. ..	..	..	..	..
77,978	3	1/8	Brush Electrical Engineering	3⅛ 3⅜	3½ 3⅝	5 6 8	..	3⅝	3
69,996	2	6%	Do. 6 per Cent. Preference	1⅝ 2⅛	1⅝ 2⅛	5 12 11	June and December	2⅛	1⅝
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5 5⅛	5 5⅛	6 7 3	January and July	5⅛	..
17,130	5	..	Edison and Swan United	.. ..	.. ..	..	—	..	..
45,000	10	6%	Electric Construction	7 7½	6¾ 7¼	..	—	8½	6¾
70,000	2	10/0	Elmore's Patent Copper Depositing	3⅞ 4⅛	3⅝ 3⅞	..	—	4⅛	3⅝
20,000	5	..	Fowler-Waring Cables (£4 paid)	2 3	2 3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	20 21	20 21	4 15 3	February & August	20¼	20
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	March & September	..	..
11,334	£10	6/1	International Okonite Limited Ordinary	7 8	7 8	..	..	..	..
11,334	£10	5/0	Do. Preference	9 9½	9 9½	8 8 9	..	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	.. ..	½ ⅝	..	..	..	..
78,949	5	2/1½	Swan United (£3. 10s. paid)	5 5½	5 5½	6 7 5	May and November	5¼	5⅛
37,350	12	12/0	Telegraph Construction and Maintenance	42 44	42 44	5 9 3	March and July	43½	42½
50,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	102 105	102 104	4 16 2	January and July	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£2. 15s. paid)	⅛ ⅜	..	..	..	..	..
—	£5	..	Do. Preference (fully paid)	3¾ 4	..	..	..	..	..
			RAILWAYS.						
50,000	£10	..	City and South London Railway	2 4	2 4	—	—	..	..

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THE ELECTRICIAN:

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NOTES.

On Monday evening last the Frankfort International Electro-technical Exhibition was closed with due ceremony. About one and a quarter million visitors have passed the turnstiles since the opening of the Exhibition in May last, and the financial results are said to afford no cause for anxiety to the guarantors. In spite of its official title the Exhibition was distinctly national, and was none the worse for being so. We all knew that electric lighting was making rapid progress in Germany, and we have now had an excellent opportunity of making ourselves acquainted with the machinery employed. German methods differ from our own, and apart from national idiosyncracies have no doubt substantial commercial reasons for so doing. Some English electrical engineers have probably returned from Frankfort with the conviction that the Exhibition was interesting rather than instructive, while others may have picked up a useful wrinkle or two. Our German friends shake their heads at some of our recent improvements; concentric cables, for example, they say they have tried, and found to be more troublesome than useful—they have got beyond them.

Perhaps the one thing which more than any other contributed to the success of this Exhibition was the, to us, arbitrary manner in which exhibitors were treated; the Executive Committee went, we believe, so far as to exclude certain exhibits on the ground that there was already enough of them. The exhibits of different firms were in this way prevented from overlapping each other, and a coherent Exhibition was the outcome; but, of course, nothing of the kind is possible in this free country. However, this and other difficulties notwithstanding, we trust our own Electrical Exhibition, now that it is irrevocably fixed for the beginning of next year, will reflect national industry as thoroughly as the one on the Main.

It seems necessary to explain that the whole of our leading article of last week was not intended to be taken *au pied de la lettre*. Mr. Kapp has, we fear, from his letter to us, not only been puzzled but rather hurt; and it is to be hoped that the pioneers in general, and the "multiphase contingent" in particular, are not quite so sensitive, and that at the worst they may be only puzzled. It seems that the statements of a professor on a no more serious occasion than a meeting of the British Association "must have caused them some anxiety;" that he was so cruel as to "dishearten them at a time when they most want support," and that these unhappy pioneers are offered "discouraging advice." We have searched the leader through for anything that can be said to be "advice," and find only these words, "If anybody wishes to transmit power for industrial purposes on the scale on which it is done at Frankfort, he has only to give an order for a reproduction of the admirable plant which is running so well." It is hardly necessary to disclaim any intention of launching the retort to which Mr. Kapp says that he lays himself open. We are by no means "convinced that the multiphase current is of little practical use;" but we think that it seems to be limited to large or difficult undertakings, where it can be well looked after, and that there is probably a great future for it for mining and other special purposes. Mr. Kapp's own word, "intricate," exactly describes the main objection which we raised. But even this is no great matter. True, an engineer will naturally avoid intricacy, but a watch is undoubtedly intricate. We could add several mechanical reasons to those which Mr. Kapp supplies to account for the delay in the delivery of the water. Every engineer knows that an engine will not run away when started on a centrifugal pump. Mr. Brown's information as to the torque of his new motor practically settles the question, but the Lauffen-Frankfort transmission cannot be said to exemplify starting on full load.

There seems to be an impression in some minds that a special license is granted to reviewers, and that a book, an author, his work, and his opinions may be dissected, criticized, and characterized as worse than rubbish, that the book-buying public may be warned off, and that nothing short of personal abuse is out of place in a review. We venture to differ with this opinion; and though there would be a serious outcry if the same treatment were offered to a new switch or dynamo, that is considered fit for a text-book, we hold that criticisms in a technical or other journal are not necessarily confined to reviews, and that when they are made, they need not be treated as gratuitous advice; on the contrary, the fee is clearly stated on the cover. The writing of leading articles would indeed be a matter of grave anxiety if "the weight of an editorial pronunciamento" fell so heavily as Mr. Kapp seems to think.

Since writing the above, we have received a letter from Mr. Brown, which is in itself a sufficient reply to Mr. Kapp.

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The method of testing the electrical efficiency of a transformer, described by Mr. Cuthbert Hall in another column, has certainly the advantage of avoiding the difficulty always arising in the measurement of the power supplied to an inductive circuit by alternate currents. Its application is, however, much limited by the fact that a suitable motor is required; and even when this can be obtained the power needed to overcome friction in the motor and dynamo may far exceed that needed for the transformer tests, so that the method becomes insensitive. In calculating the efficiency Mr. Hall makes no distinction between the two transformers, though one is transforming up and the other down, and the former works at a greater load than the latter. That it is sometimes quite wrong to assume that the losses in the two transformers are equal is clearly shown in the last case referred to. If the losses are equal the efficiency of the step-up transformer is 50 per cent. at a load of 268·875 watts; whereas, according to the immediately preceding test, the efficiency is as much as 67 per cent. for a *smaller* load of 206 watts.

The Edison Pressure Indicator is the latest thing in the United States. Most of the electrical journals illustrate it, but the description is even more vague than is usual with our American contemporaries. The instrument is contained in a box, and is apparently made to hang against the wall. It is surmounted by two glow lamps, one marked Test, the other Work. Below these is a handle or lever, and another one, barrel-organ fashion, is to be found on the side of the box. A glass pane allows a drum or curved scale to be seen, and in front of this is a pointer. A scale, marked from 100 to 120, with an index sliding in a slot, is fastened to the front of the box. Below this is a label—"Never leave the test lamp burning," and below this again is another slot and a sliding index, which has nothing but the letters of the legend to point to. Three ventilating holes under the organ handle suggest that something gets warm inside. We have read all the "descriptions"; they chiefly consist of information of this kind:—"Dim lamps can never be satisfactory; neither will lamps operated at a high pressure, as they deteriorate and break." We can only make a guess as to what it is all about, and yet people say that we have nothing to learn from Americans! We believe it to be a substitute for an engine-room voltmeter.

The regulator socket for glow lamps, which will be found described in our American notes column, is certainly ingenious, but it is not clear that any perceptible saving will be effected by its use. Even if the meter correctly indicate the power supplied by the alternate current, the efficiency of lamps when burnt very much below their normal brightness is so low that the saving is hardly worth consideration. The candle power of lamps varies roughly as the sixth power of the voltage and as the cube of the watts supplied, so that when the illumination is reduced to about one-half of its normal amount the power absorbed in the filament is only reduced by about 20 per cent. But with most meters the power supplied under these circumstances will be over estimated. Coulomb meters measure current without reference to the voltage, so that the volts absorbed by the choking coil, which correspond in reality with but a very small amount of energy, will be fully charged for; while such alternating-current wattmeters as exist are not at all correct when used on inductive circuits, owing to the difference of phase set up between the current and the volts. The saving as recorded on the meter would probably be less than 10 per cent. It is true that the impracticability of turning down a glow lamp has been treated by its opponents as a defect, but precisely the same defect is to be found in most oil lamps, and even with gas jets the object is not so much to economise as to avoid the trouble of relighting. With electric lamps this trouble does not exist. Is it possible that, knowing the reduction in power is nothing like so great as the reduction in light, and being aware that even first-rate meters as at present constructed change in favour of the company when choking coils are used, this is an ingenious device of a central station manager to encourage a saving of an imaginary character?

Hammersmith Vestry.—This Vestry has decided not to apply for a Provisional Order.

Rio Janeiro.—We learn from *Industria é Invenciones* that an electric tramway is being built in Rio Janeiro.

Battersea.—The Vestry have appointed a special committee to consider the question of lighting the parish by electricity.

Prof. von Helmholtz.—The German Emperor has appointed Prof. von Helmholtz a member of the Privy Council, with the title of Excellency.

Electric Cranes.—An electric crane has been built for the Petersenquai at Hamburg. The current is supplied from the central station on the quay.

The Khotinsky Lamp.—Captain Khotinsky, of the Gelnhausen Incandescent Lamp Works, has proceeded to Brazil in order to start a lamp factory in that country.

Institution of Electrical Engineers—Annual Dinner.—The third annual dinner of this Institution will be held at the Criterion Restaurant, Piccadilly, on Friday, November 13th.

Appointment.—Electric Inspector.—The London County Council is about to appoint an electric inspector at a salary of £200 a year. For further particulars see our advertisement columns.

Church Service by Telephone.—On Sunday, the 11th inst., the whole of the morning service at Christ Church, Birmingham, was successfully transmitted by telephone to the Loughborough exchange.

Preston.—The National Electric Supply Company has resolved to put down mains and erect a central station. It is estimated from orders in hand that the company will start with about 7,500 lights.

Personal.—Mr. D. Morgan Lewis, M.A., Demonstrator of Physics in the University College of North Wales, Bangor, has been elected to the Professorship of Physics in the University College of Wales, Aberystwith.

International Telephonic Communication.—At the beginning of next year telephonic communication will be opened between Brussels and Amsterdam (125 miles). The line will pass through Antwerp and Rotterdam.

Interurban Telephone Extensions in Germany. — The Berlin-Eberswalde and Hamburg-Magdeburg (130 miles) telephone trunk lines are now completed, and will be opened to the public in the course of a few days.

Glasgow.—On the recommendation of Sir William Thomson, the Glasgow Corporation Electric Lighting Committee have asked Prof. A. B. W. Kennedy to devise a scheme of electric lighting for the compulsory area which is scheduled in the Glasgow Provisional Order; and that gentleman has agreed to act as requested.

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Dover.—A local company is to be formed, under the auspices of the Brush Company and the Town Council, to take over the municipal electric lighting order and supply current for both public and private lighting purposes.

Lightning.—The vicarage of Woodville, near Burton-on-Trent, was struck by lightning during the storm on Thursday last week. The chimney was utterly demolished, and a portion of the roof stripped.—The central tower of Lichfield Cathedral was struck by lightning last week, but up to the present no serious damage has been discovered.

Electric Lighting in Berlin.—The report of the Berlin Electrical Works shows that from June 30, 1890, to July 1, 1891, there was a large increase in the number of consumers, namely, from 872 to 1,314, being about 44 per cent.; the connected lamps have increased from 74,959 to 104,100, and orders for an additional 25,000 to 30,000 lamps have been secured for next winter.

The Chicago Exhibition.—Forms of application for space and prospectuses with detailed information are now in preparation, and will be sent out almost immediately. In the meantime, intending exhibitors can apply to the Secretary of the Royal Commission, Society of Arts, John-street, Adelphi, and their names will be noted at once, with a view to their receiving early copies of the prospectus when ready.

The London County Council and Electric Light Wires.—At the last meeting of the Council the Parliamentary Committee reported that they had instructed the Council's agent to prepare a Bill giving the Council power to require that where there are subways in any thoroughfare, gas, water, electric light, and other companies shall lay their pipes, wires, &c., in such subways, and shall pay the Council a rent for using them.

Glasgow Town Council and Mechanical Haulage.—The deputation of the Glasgow Town Council who visited the Frankfort Exhibition, and who have had interviews with representatives of the General Electric Power and Traction Company and of the Electrical Power Storage Company, have reported in favour of the adoption at an early date of mechanical haulage (cable or electric) on the Glasgow tramway system.

Institution of Civil Engineers.—Premiums Awarded.—The following are some of the premiums awarded by the Council of this Institution for original communications submitted during the past session:—Telford Medals and Telford Premiums to Messrs. Llewelyn B. Atkinson and Claude W. Atkinson for their joint Paper on "Electric Mining Machinery;" a Telford Medal and a Telford Premium to Mr. R. E. B. Crompton for his Paper on "The Cost of the Generation and Distribution of Electrical Energy;" a Telford Premium to Mr. William Langdon for his Paper on "Railway Train Lighting."

The Crystal Palace Electrical Exhibition.—We are informed that the requests for space—which already exceed a total of 200—include electric lighting plants for country and town houses, for mines, for steamships, for railway trains, and for private carriages. The newest forms of motors, generators, accumulators, and other machinery employed for producing and storing electricity are to be shown. Not only will the most eminent British electrical and engineering firms, with scarcely an exception, be represented, but several of the more important exhibits at the Frankfort Exhibition will be transferred to the Crystal Palace.

Obituary.—The Abbé Jean Caselli died a few days ago at the Santa Maria Hospital in Florence. He was born at Sienna in 1815, and took orders when he was twenty. After having made politics his study for some time, he devoted himself entirely to science, and in 1856 he achieved celebrity by his invention of the *pantelegraph*, in which, by a combination of styles oscillating in synchronism over drums covered at the transmitting end with metallised paper, and at the receiving end with Bain's chemical paper, handwriting and designs could be reproduced facsimile at a distance. Caselli's ingenious system was in use for some years at Havre and Lyons, but difficulties of synchronism and the frequent illegibility of the despatches led to its abandonment.

Telegraphic Communication with Lighthouses.—At the August meeting of the Cape Town Chamber of Commerce the attention of the management committee was called to the advisability of having telegraphic communication with Dassen Island, some 30 miles north of Table Bay. It was stated that if there had been smart communication on the Saturday preceding the day of the Chamber's meeting, property to the value of £80,000 might have been saved. Although a lighthouse is going to be built on the island, it was thought that there should in the interim be telegraphic communication with Cape Town, and that a short sea line might be laid down from Dassen Island to Izyerfontein, a distance of five miles in shallow water, and from there to Malmesbury, at a cost of £1,700. The matter was referred to the management committee.

Paper on Hertzian Oscillations.—In the list of subjects upon which Papers may be addressed to the Dutch Society of Sciences of Haarlem, up to January 1, 1893, it is stated that since Hertz's researches it has become very important to determine the period of the oscillations generated in conductors of different shapes; and the Society, therefore, calls for a communication setting forth either the necessary equations for a few cases, or the results of experiments made with this object in view. The Papers must be anonymous, and must *not* be in the author's own handwriting; they may be written in Dutch, French, Latin, English, Italian, or German, and must be sent, accompanied by a sealed envelope containing the author's name, to the Secretary of the Society, M. J. Bosscha. The writer of the best essay may have either a gold medal or 150 florins.

The Tommasi Accumulator.—In the *Comptes Rendus* of October 15, M. D. Tommasi has a brief note on his "multitubular" accumulator (*Electrician*, Vol. XXVI., p. 130), the distinguishing feature of which is that the electrodes consist of rows of perforated tubes (lead, ebonite, porcelain, or celluloid), filled with active material, and suspended from slots in the lid. M. Tommasi claims that by reason of the thorough utilisation of the active material, the weight of one of his cells is, *ceteris paribus*, from two to six, and the volume from four to eight times less than that of an ordinary accumulator. The maximum permissible charging current is as high as 60 amperes per kilogramme of plate (27·3 amperes per pound). For traction purposes, M. Tommasi prefers rectangular celluloid tubes; and for lighting work he finds leaden rectangular tubes give the best results. A capacity of 16 ampere hours per kilogramme (7·3 ampere hours per lb.) of electrode is claimed.

Paignton (Devon).—We learn that Mr. William Robertson, the Director of the Paignton Promenade Quay and Torquay Ferry, contemplates the introduction of electric launches in Torbay. It is also proposed to lay down electric plant to light Paignton. At a meeting of the Local Board on Monday the question of electric lighting was the principal subject discussed. It arose from a letter received from Mr. Robertson, who said that in order to charge the electric launches he proposed running between Paignton and Torquay it was necessary to put up a charging station properly equipped with steam engines of sufficient power and suitable dynamos. The same establishment could, he pointed out, be arranged so as to supply electric light to the town of Paignton, or to certain portions of it. Before deciding upon the power of the engines and dynamos to be put down, Mr. Robertson said he should be glad to have the views of the Local Board on the subject. The matter was referred to a committee.

Institution of Civil Engineers.—Subjects for Papers.—The following are some of the subjects upon which the Council of the Institution of Civil Engineers invites original communications:—The Continuous Running of Steam and other Engines, with details of construction; the Increased Efficiency to be derived from Superheated Steam; the best Arrangement of Engine for any given Electric Light Station; the Application of Electricity to the Treatment of Sewage; the Electro-Deposition of Copper; Pyrometers of various kinds, the different objects they are applied to, and their practical use and working; Electrical Traction for Roads and Railways, and the adaptation to such purposes of the vehicles at present in use;

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Electrical Motors for (*a*) Inland Navigation, (*b*) Ocean Vessels; the most suitable Form of Electric Light Mains, having regard to durability, economy of conducting material, and facility of making and laying house connections; the Application of Electricity to Smelting and Metallurgical Operations; Electrical Measuring Instruments—such as Ammeters, Voltmeters, Power-meters and Supply-meters.

Electric Coal Mining in America.—Electric coal mining machines were introduced in the Monongahela coal fields, according to the *Electrical Age* of New York, nearly two years ago, since which time they have been rapidly adopted. One of the latest mines to be operated with these machines is the O'Niel and Peterson mine at Bunola, on the Pittsburg and Belle Vernon Railroad, on the Monongahela River. The contract for equipping the Bunola mine was made with the Michael's Electric Coal Mining Machine Company, of Pittsburg. The plant consists of one 50 H.P. steam-engine, one 30 H.P. Westinghouse alternating-current generator, and eight mining machines, with the Tesla motor of the Westinghouse Electric and Manufacturing Company attached to each. The success of the Michael's coal mining machine, says our contemporary, has long passed the experimental stage, as it has been in practical operation for fifteen months. The capacity of each machine per day is 65 tons of coal, or about one square foot of undercut per minute for ten hours each day.

Dynamos and Accumulators in Telegraph Work.—At a recent meeting of the Vienna Electrotechnical Society Herr E. Kœffler read a Paper on the subject of the employment of dynamos and accumulators for telegraph purposes. Herr Kœffler is against the use of dynamos, their great first cost and the cost of maintenance and superintendence only permitting of their economical employment where, as in the United States, comparatively strong currents are used. The author admits, however, that the substitution of dynamos for batteries at the Central Telegraph Office at Paris has effected a saving. The examples of the London and Berlin telegraph offices are cited in support of the economy of accumulators. By employing 12 ampere-hour storage cells on open circuit lines, and 50 ampere-hour cells on closed circuit lines at the Vienna Central Telegraph Office, Herr Kœffler makes out a saving of 38 per cent. over Daniell cells, in the case of busy wires. He also alluded to the new departure now being made in Germany, where, at the numerous translating stations between overhead and underground lines, which exist in that country, accumulators are substituted for primary batteries.

Frankfort Exhibition.—Our Frankfort correspondent writes us that the Exhibition was closed on Monday night, October 19th. The number of visitors has exceeded 1,200,000, which is about the estimated number. It is thought that the finances will, when everything is settled up, be found satisfactory, and that it will not be necessary to call upon the guarantors. The testing jury is at present at work on the Lauffen-Frankfort transmission plant, and they will probably push the voltage gradually higher and higher till the insulation breaks down. Siemens and Halske made some experiments on Saturday with a pressure exceeding twice that used by them up till then, in the high-voltage experiments they have been showing during the course of the Exhibition. Two oil-insulated transformers were connected in series, and current was taken at 2,000 volts from their large alternator, and transformed in each transformer up to 20,000 volts. Four hundred 100 volt glow-lamps in series showed that the pressure of 40,000 had been reached. The Siemens (London) cable held out, even though at one time 48,000 volts were on. It is remarkable that the arc produced by this enormous pressure was inferior in point of brilliancy to that made by half the pressure.

Crystal Palace and Sydenham District.—On Saturday last the foundation stone of an electric light generating station in Wells-road, Sydenham, was laid by Col. L. V. Loyd, chairman of the Electric Installation and Maintenance Company, in the presence of a large and influential gathering of residents and friends, who afterwards partook of luncheon at the Crystal Palace. The speeches were received with much enthusiasm, the project being very popular in this locality. The station building will be 80ft. long by 70ft. wide, and the plant will comprise five 160 H.P. engines, each driving a direct current dynamo of the Parker type. This plant will be able to supply about 20,000 8 c.p. lamps. The system adopted is that of continuous current transformer sub-stations feeding into a low-pressure network. Storage batteries will also be used. In the first instance, about 500 H.P. will be transmitted electrically from the generating station to the Crystal Palace, which is about 1¼ mile distant, in connection with the Electrical Exhibition. The plant is being laid down by the Electrical Installation and Maintenance Company, the contractors being Messrs. J. E. H. Gordon and Co. The order for the work was given to the contractors at the end of August last, and the building was commenced on September 16th, and is expected to be roofed in in about a fortnight. The whole of the electrical and steam plant is ready, and will be delivered as soon as the building is in a condition to receive it.

Electrical Exhibition at St. Petersburg.—MM. J. Pierson Fils, of 2, Rue de Canteleu, Lille, and 13, Wladiminsky-prospect, St. Petersburg, inform us that they have been appointed representatives of the Société Imperiale Polytechnique Russe in connection with the forthcoming Electrical Exhibition at St. Petersburg, organised by that body. The Exhibition will be held in the centre of the capital, and will be opened about the middle of December next, closing March 15, 1892. For the first time in the history of Russia foreign firms have been granted the Imperial permission to exhibit; and applications for space have, it is stated, already been received from Ganz and Co., Siemens and Halske, MM. Richard Frères, the Société Générale des Téléphones, the Compagnie Continentale Edison, &c., &c. The principal object of the Exhibition is said to be to enable the Russian Government to choose the best system, with a view to the inauguration of comprehensive electric lighting schemes in the principal towns of Russia. The charge for floor space is at the rate of 36fr. per square metre, 18fr. per square metre being asked for wall space. Exhibitors are recommended to insure their exhibits. Exhibits will not be allowed to be sold and handed over immediately to the purchaser without the permission of the Executive Committee, to whom 10 per cent. on the selling price will have to be paid. Foreign exhibits will be allowed to enter Russia duty free on the condition that they recross the frontier within a month of the close of the Exhibition. All objects sold at the Exhibition will have to pay the usual duty. The railway companies have granted a reduction of 50 per cent. on their usual transport charges in the case of all goods intended for the Exhibition.

The St. James and Pall Mall Company.—The following letters appeared respectively in *The Times* of Monday and Tuesday last:—

TO THE EDITOR OF "THE TIMES."

SIR: It is early, but not, I think, premature, to warn the public, and especially the sanitary authorities, of an intolerable nuisance and a seemingly great danger with which we are threatened by the extended use of the electric light. In Mason's-yard, St. James's-square, there is an engine-house of one of the companies, the machinery of which has been in use for some time, and until quite recently with no reason to complain of or to suspect any mischief from it. But the increased use of the light and the shortening of the days are now throwing more and more work upon the engines, and there is hardly any room to doubt that to this is due an effect upon the sewers which is becoming unendurable and probably perilous. As the night advances the smell as from drains continually increases, until soon after midnight it becomes strong enough to awake many from their sleep and make them feel (as they say) "quite ill." It is supposed that this arises from the forcing of waste steam into the sewers; but even if it should be attributable only to that steam itself, unconnected with sewage, it is so bad as an olfactory nuisance, if not as an atmospheric poison, as to demand prompt and decided measures on the part of the parochial authorities to put an end to it.

October 17th. PICCADILLY.

SIR: My attention has been drawn to a letter under the heading, "A Nuisance in St. James's," in to-day's issue of *The Times*.

Your correspondent "Piccadilly" should in fairness have taken the trouble to inquire into the cause of the alleged nuisance before committing himself to print, as he might easily have ascertained that my company does not, either at its station in Mason's yard or elsewhere, force any waste steam into the sewers, but discharges it from a chimney shaft at a height of 130 feet above the ground.—I am, Sir, yours obediently,

F. J. WALKER, General Manager.

The St. James's and Pall-mall Electric Light Company (Limited), Mason's-yard, Duke-street, St. James's, S.W., October 19th.

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MAGNETISM IN IRON AND OTHER METALS.*—LIV.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 664.*)

§ 186. **Effects of Repetition of Magnetic Processes.**—Space may be found here to refer shortly to one or two of the minor phenomena of magnetisation, which the molecular theory goes far to make intelligible.

A consequence of the irreversible displacements which the molecular magnets suffer, together with the fact that the stability of each molecule depends on the configuration assumed by many molecules in its neighbourhood, is that in general a magnetising process has to be repeated more than once before its effects become strictly cyclic. In some cases a progressive change may be traced even during many repetitions of the process.

For instance, let a magnetising force be applied to a piece of soft iron, the strength of the field being regulated so that it brings the metal into what we have called the second stage of the magnetising process, when many of those molecules which are not already upset are on the verge of being upset. Let the force then be removed and reapplied. The configuration of the group during this re-application is by no means the same it was during the first application, and accordingly we may expect that some of the molecules which were just able to stand in the first instance yield in the second owing to the changes which have meanwhile taken place in the grouping of their neighbours. The re-application of the magnetising force may therefore be expected to produce a somewhat stronger magnetisation than was produced when the force was first applied. To a less degree, a third application of the force should make the magnetisation rise a little higher still, and so on.

Similarly, the second removal of the force should leave more residual magnetism than is left after the first removal. But we may expect that the limits between which the magnetism changes when the magnetising force is applied and removed will come to be closer in each repetition of the process; the molecular "accommodation" which goes on as one after another of the doubtful molecules is upset has the effect of narrowing the range through which the magnetism alters in succeeding cycles.

That these anticipations are in accord with the results of experiment will be seen from the following paragraphs, mainly extracted from a Paper which was written without reference to the light which the molecular theory throws upon the matter.†

When a magnetising force is first applied, then removed, and then re-applied, whether suddenly or gradually, the resulting value of I is somewhat higher than that reached by the first application. A third application gives a somewhat higher value, and so on, the effects apparently approaching an asympotic limit. This appears to have been first shown by the experiments of Fromme.‡ At each removal of the magnetising force the residual magnetism is also left somewhat greater than before. And this second action (the increase of the residual magnetism) exceeds the increase of the induced magnetism, with the result that the changes of magnetism between residual and induced diminish in range with successive removals and re-applications of the magnetising force.

The following observations (Table XXXIII.) were made by the ballistic method on a long piece of soft annealed iron wire. The readings are given without reduction to absolute measure; they relate to a point which falls early in the steep part of the curve of magnetisation.

Similar results were repeatedly obtained, both with freshly annealed wires and wires from which a previous strong magnetism had been shaken out by tapping. In curves showing the relation of B or I to H the same thing exhibits itself in what may be called the over-closing of loops formed by removing and re-applying a given value of H. A good example of this is furnished by Fig. 44, §78, which shows how much more considerable the action now spoken of is at early than at late stages of the magnetisation.

Table XXXIII.

Magnetising current.	Throw of ballistic galvanometer.	Magnetism. Induced.	Residual.
First made	203	203	...
broken	−53·6	...	149·4
made	+54·2	203·6	...
broken	−47·8	...	155·8
made	+48·7	204·5	...
broken	−45·7	...	158·8
made	+46·6	205·4	...
broken	−44·9	...	160·5
made	+46·1	206·6	...
broken	−44·0	...	162·6
made	+45·6	208·2	
After many makes and breaks—			
broken	−42·6		
made	+43·1		
After many more makes and breaks—			
broken	−39·5		
made	+39·8		

The following experiment (Table XXXIV.) (also on annealed iron) shows that the same kind of action occurred when the current was slowly changed by the liquid rheostat of Fig. 17, §41, and the magnetism was determined by a magnetometer:—

Table XXXIV.

Magnetising current.	H	Magnetometer deflection.	I Induced.	I Residual.
Gradually raised to 70	2·46	93	298	...
,, reduced to 0	0	65	...	208
,, raised to 70	2·46	97	310	...
,, reduced to 0	0	70	...	224
Then 100 sudden makes and breaks—				
Suddenly raised to 70	2·46	103	330	...
,, reduced to 0	0	80	...	256

Incidentally, this experiment illustrates another point—that the amount of magnetisation gained or lost by applying or removing a given magnetising force is greater when the change of force is sudden than when it is gradual. Other instances of the same thing will be found in the experiment quoted below.

Table XXXV.

Magnetising current.	Magnetometer deflection.	Remarks.
0	0	
Gradually raised to .....+190	+146	Here there is gradual diminution of range. This part of the operation is shown in Fig. 154.
,, reversed to .....−190	−141	
,, ,, ,, ...+190	+127	
,, ,, ,, ...−190	−133	
,, ,, ,, ...+190	+120	
,, ,, ,, ...−190	−132	
Suddenly ,, ,, ...+190	+124	Here there is an increase of range due to the suddenness of these reversals.
,, ,, ,, ...−190	−136	
,, ,, ,, ...+190	+123	
Fifty double reversals, then—		But after repeating the sudden reversals often enough the range becomes smaller than ever.
Suddenly reversed to .....+190	+111	
,, ,, ,, ...−190	−127	
Then gradually ,, ...+190	+108	And a *gradual* repetition of the cycle causes still a further reduction of range.
,, ,, ,, ...−190	−126	

When a magnetising force is applied and then repeatedly *reversed*, the changes of magnetism, instead of being strictly cyclic, form what may be termed unclosed loops. An instance of this is given by Fig. 52, § 82, which shows a series of these unclosed loops in the magnetisation of steel wire. The result

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† *Phil. Trans.*, 1885, p. 570, §§ 54-58.

‡ Pogg. *Ann.*, Ergbd. vii., 1875, and Wied. *Ann.*, iv., 1878.

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is, as in the case of repeated removals and reapplications of magnetising force, that successive repetitions of the process give a gradually diminishing range of magnetic change. This action, like the one just described, occurs most conspicuously at points in the early part of the curve of magnetisation. The observations in Table XXXV. were made specially to exhibit it, on a piece of annealed iron wire, 400 diameters long, by the magnetometric method.

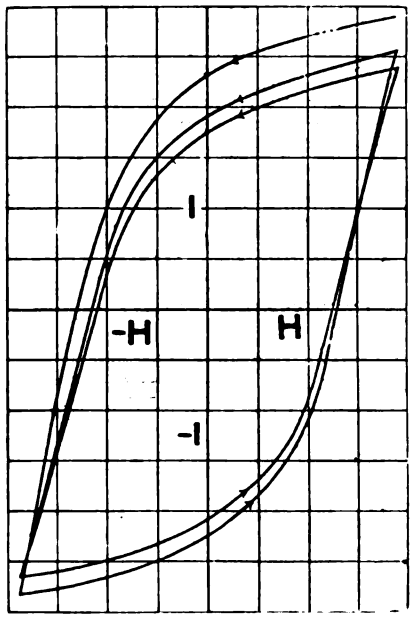

Fig. 154.—Repetition of Magnetic Cycles in Annealed Iron Wire.

In the first part of the above operations, during the five gradual reversals of magnetising force, intermediate readings were taken, which enabled the curves shown in Fig. 154 to be drawn. These show at a glance the manner in which the range of magnetic change diminishes. Sudden reversals, following on these, cause at first an increase of range, thus illustrating the comparative effects of gradual and sudden change of H, but on being repeated many times they reduce the range to a lower value than before.

demagnetised by reversals. It shows that the changes of magnetism are now cyclic. The same result was given by other specimens, which when freshly annealed gave much diminution of range, but when demagnetised by reversals after the magnetising force had been raised to a high value, were found to have lost this property. In this respect, then, a wire demagnetised by reversals differs from the same wire in its primitive annealed

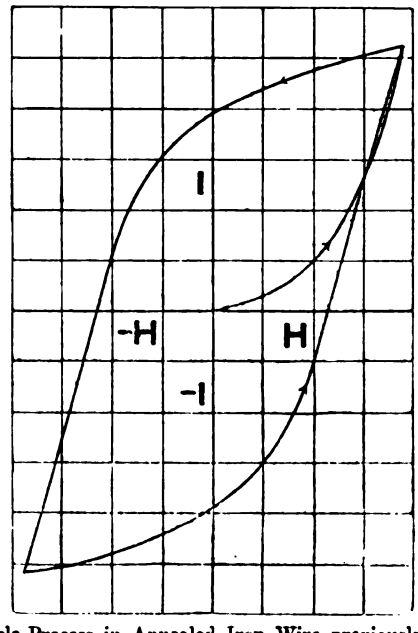

Fig 155.—Cycle Process in Annealed Iron Wire previously demagnetised by reversals.

state. It will be seen, too, by comparing figures 154 and 155, that the unsymmetrical susceptibility with respect to forces of opposite signs which exists in the annealed wire has given place to a very perfect symmetry after demagnetisation by reversals. Re-annealing the wire restored all the characteristics of the primitive state.

The following observations (Table XXXVI.), made with another piece of annealed iron wire at a part of the curve very sensitive to the actions now spoken of, show well the reduction of

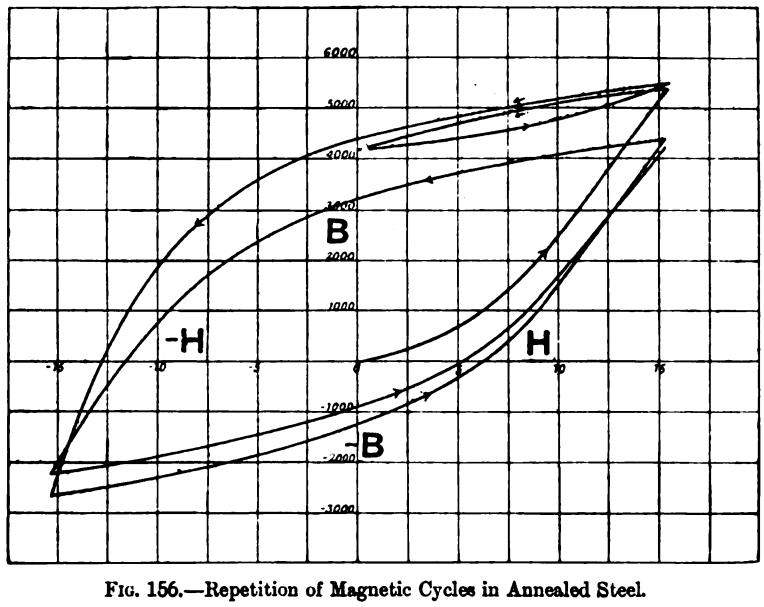

Fig. 156.—Repetition of Magnetic Cycles in Annealed Steel.

The same piece of wire was next subjected to a magnetising force about five times greater than the above, and was then demagnetised by reversals. Experiments similar to the above were then made on it, when it was found that *the tendency to a diminution of range with repetition of a cyclic alteration of magnetising force had disappeared.* The diagram, Fig. 155, shows the effect of applying, reversing, and re-applying the same magnetising force as in the former case, after the wire had been

range by reversals and then the rise of magnetism, induced and residual, which is produced by successive removals and re-applications of H. This last occurs in a very marked way after the range of magnetic change has been reduced by reversals of H. The two directions of the current will for brevity be distinguished as A and B. The changes were sudden, and the magnetism was determined by the direct magnetometric method. A want of symmetry is very noticeable here between the positive mag-

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netisation due to the current A, which is first applied, and the subsequent negative magnetisation due to the equal and opposite current B.

Table XXXVI.

Magnetising Current.	Magneto-meter deflection.	Remarks.
Made A	+232	
,, B	−110	Diminution of range by reversals.
,, A	+180	
,, B	−101	
,, A	+172	
,, B	−100	
Twenty reversals, then—		
Made B	− 95	
,, A	+158	
Broke A	+150	Rise of magnetism (induced and residual) by successive removals and re-applications of H.
Made A	+200	
Broke A	+193	
Made A	+206	
Broke A	+201	
Twenty makes and breaks, then—		
Broke A	+205	
Made A	+209	
Then reversals again—		The diminution of range by reversals is again conspicuous.
Made B	−105	
,, A	+178	
Forty reversals then—		
Made A	+163	
,, B	−105	
Broke and remade B	−136	
Ditto twenty times	−175	

The magnetisation of steel exhibits, even more than that of iron, reduction of range with successive reversals of H, and want of symmetry between the values of I induced by successively applied + and − values of H. Fig. 156 shows the changes of magnetism which were undergone by an annealed steel wire when a magnetising force of 15 C.-G.-S. units was applied, removed, re-applied, reversed, and re-reversed twice. The want of symmetry between the positive and negative values of the magnetism is very marked in this example: the steel acquires a strong magnetic *set* towards the side of the first magnetisation.

(To be continued.)

THE ELECTRICAL EFFICIENCY OF A SMALL TRANSFORMER.

BY H. CUTHBERT HALL.

The subject of the efficiency of transformers is one which has received a good deal of attention of late, and, at the discussion at the Institution of Electrical Engineers last session on Mr. Swinburne's Paper, the need of more conclusive tests of transformer efficiencies was much emphasised.

Of the three methods commonly adopted for the determination of the efficiency of transformers, the Blakesley split-dynamometer method is perhaps the most convenient, calorimeter tests requiring many observations and almost innumerable corrections, and determinations, involving the measurement of coal and water consumption and engine-efficiency, being only applicable to cases where large numbers of transformers are at the disposal of the experimenter.

The method of testing transformers by measuring the watts required to drive a direct-current motor, driving an alternator to which transformers are attached, is one to which few theoretical objections can be made, and which offers, comparatively speaking, but trifling practical difficulties.

The advantages of this method, as pointed out by a recent correspondent to one of the electrical papers, are that the energy absorbed can be measured in direct current units, and that an approximately accurate test can be made of a transformer of low power.

The results of some tests made on some ·75 kilowatt transformers by this method may, perhaps, prove not uninteresting. The transformers with which the experiments were made were of a well-known closed-circuit type, and the precaution was observed of testing several transformers of the same horse-power (·75 of a kilowatt), in order that any defect in the workmanship of any particular transformer might not prevent a correct decision from being arrived at with regard to the general efficiency of the class of transformers to which the one under test belonged. The sequel, however, proved that this precaution was unnecessary, as the results of the tests were so nearly identical that it has not been thought necessary to publish more than one typical case.

The author had not at his disposal a high-tension alternating-current dynamo of a suitable size; accordingly, a low-tension alternator was used, and the device of transforming up, and down again was resorted to. Therefore, in computing the loss of energy in one transformer, the figures obtained for the total loss had to be divided by two.

The accompanying diagram shows the general arrangement of the direct-current motor, alternating-current dynamo, transformers, and measuring instruments.

A is the direct current motor, B the alternating-current dynamo, C and C_1 the transformers, D the lamps, E the switch between the second transformer and the lamps, G the voltmeter on the secondary of the second transformer, K the ampere-meter in the lamp circuit, and M the voltmeter on the terminals of the alternator B. N is the battery of secondary cells, driving the direct-current motor, and H and J are the direct-current instruments (ammeter and voltmeter) on the battery-motor circuit. The cells which were used for exciting the field-magnets of the alternator B are represented by the letter O. An ampere-meter and a regulating resistance were inserted in the field-magnet circuit, in which the current was thus kept constant throughout the tests. F represents the ampere-meter, and R the regulating resistance.

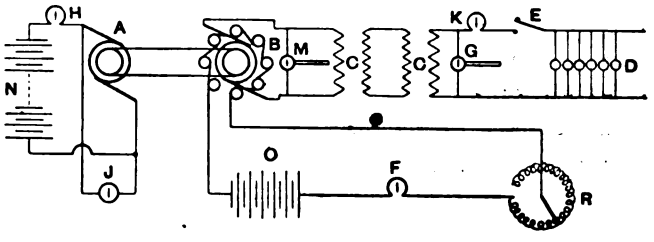

Diagram of Arrangement of Motor, Dynamo, and Transformers.

All the instruments were very carefully calibrated and were placed in positions as far from any disturbing influences as possible. Hot wire voltmeters were used on the alternating circuit, and Evershed's ampere-meters. A Schückert voltmeter was employed to measure the potential difference of the batteries driving the direct-current motor.

The insulation resistance between the primary and secondary coils of each transformer, and between the primary and secondary coils and the core, was carefully measured both before and after the load had been put on, and in every instance the insulation resistance exceeded 60,000 megohms. The insulation tests were made with an Elliott reflecting galvanometer and a battery having an electromotive force of 200 volts.

The speed of the alternator was kept constant, and regulated to give a frequency of 67, that being the frequency for which the transformers were designed.

The transformers were designed to give ·75 of a kilowatt on full load, and to transform from 2,000 volts on the primary circuit to 100 volts on the secondary.

The watts required to drive the motor with various loads on the secondary of the second transformer were as given in the table below:—

No. of lamps on C_1.	Watts driving direct-current motor.
3	1997·5
6	2220·4
8	2364·25
9	2437·5
12	2772·0

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The efficiency of the motor alternator combination varied slightly with different loads, and had to be determined by putting various numbers of lamps direct on to the alternator.

The alternator was loaded with lamps direct until the direct-current motor watts were as nearly as possible 1997·5. The combined efficiency of the motor and alternator was then calculated from the number of lamps on the alternator and from the direct-current watts, and was found to be 30·33 per cent. The numbers of lamps which the alternator would carry when the direct-current motor was receiving respectively about 2220, 2364, 2437, and 2772 watts were also observed, and the combined efficiency of the motor and alternator calculated at these loads. The results obtained are given in the table below:—

No. of lamps on alternator.	Calculated lamp-watts.	Voltage of lamps.	Watts to motor.	Combined efficiency of motor and alternator.
15	900	100	2843·4	31·65
13	780	100	2470·7	31·57
12	720	100	2285·7	31·50
11	660	100	2170·3	30·41
10	600	100	1978·2	30·33

It will be seen that the efficiency of the motor-alternator arrangement varied very little for loads corresponding to those which were on the motor when transformer C_1 had 3, 6, 8, 9, or 12 lamps attached to its secondary, the lamps forming but a small part of the total load on the motor. Therefore, in calculating the efficiencies of the transformers at various loads, it would have been approximately correct to have considered the efficiency of the motor-alternator combination as 31 per cent.; but, in order to achieve greater accuracy, the actual values given above have been taken in each case.

The efficiency of the motor-alternator arrangement having been determined, the efficiency of one transformer at various loads could be calculated from the data supplied in the table given below:—

No. of lamps on C_1.	Voltage of lamps.	Calculated lamp-watts.	Watts to motor.
12	100·5	727·2	2772
9	102	551·8	2437·5
8	102	499·4	2364·25
6	105	396·9	2220·375
3	107	206·0	1997·5

The watts required to drive the motor when twelve lamps were on the secondary of C_1 were 2,772, and the combined efficiency of the motor-alternator arrangement at this load is 31·65 per cent.; therefore, 68·35 per cent. of the total energy supplied to the motor is lost in the motor and alternator, the remaining 877·33 watts being supplied to transformer C. The watts delivered to the lamps are 727·2; therefore, the efficiency of the two transformers is 82·8 per cent.; and therefore 17·2 watts per cent. are lost in the two transformers, and 8·6 watts per cent. in one transformer. Therefore the efficiency of one transformer at full load is 91·4 per cent.

For nine lamps the watts required to drive the motor are 2437·5, and the efficiency, of the motor-alternator combination is 31·57 per cent.; therefore, the efficiency of the two transformers is 73 per cent., and of one transformer 86·5 per cent. For eight lamps the watts to the motor are 2364·25, and the efficiency of the motor-alternator combination at this load is 31·5 per cent.; therefore, the efficiency of one transformer is 83·8 per cent. With six lamps and three lamps on C_1, it will be seen that the efficiency works out at 79·35 and 67 per cent. respectively.

The watts required to drive the direct-current motor when transformer C_1 was on open circuit were 1792·5. Taking the combined efficiency of the motor and alternator at 30 per cent., the watts lost in the two transformers are 537·75, and in one transformer 268·875, which is 35·8 per cent. of the power of the transformer at full load.

The results for the efficiency of the transformer at various loads are for convenience tabulated below.

No. of lamps on C_1.	Voltage of lamps.	Calculated lamp-watts.	Efficiency of transformer.
12	100	727·2	91·4 per cent.
9	102	561·8	86·5 „
8	102	499·4	83·8 „
6	105	396·9	79·35 „
3	107	206·0	67·0 „
0	...	...	35·8 per cent. of the power of the transformer at full load lost.

THE FRANKFORT EXHIBITION.—XIV.

(FROM OUR SPECIAL CORRESPONDENT.)

Several electric trams have been running during the past five months between the Exhibition and the Opera Place. It was arranged that the line should be constructed and equipped by Siemens and Halske, and this firm arranged with the Frankfort Tramway Company to lend and lay down the rails, while they themselves undertook the remainder of the work.

The line is 1,440 yards long, and is fairly level, there being only one sharp curve of about 13 yards radius. The overhead wire system is employed, the wires being carried on iron poles 18ft. high. The current is supplied at a pressure of 800 volts from the Machinery Hall by two cables of 70 sq. mm. cross-section (·11 sq. in. nearly). One of these is attached to the rails at the Exhibition end, and wherever two rails join they are connected electrically by a copper wire sunk beneath the surface.

The other cable runs by the side of the line close to the posts, 1ft. 8in. below the surface for a distance of 650 yards. Through every alternate post an 18 sq. mm. (·028 sq. in.) sectional wire is drawn, one end being connected with the cable, and the other with the trolley wire. The far end of this underground cable is brought out and connected with a 50 sq. mm. (·08 sq. in.) bare cable, which runs from here along the top of the insulators of the poles on the left side of the line to the end. At every pole this cable is electrically connected with the long working wire. The idea of using both underground and overhead cables is to show that the firm can supply either. There are three sidings on the line, dividing the line up into five fairly equal parts. The points shut automatically by means of springs, no pointsmen being required, the wheels wedging the points apart or being led by them to the siding, where the tram has to wait till the one coming in the opposite direction has passed.

Means are provided by which the driver can communicate with the engineer, and summon help in the event of a breakdown. Both the long working wire and the wires which support it are of galvanised iron, and are 6 sq. mm. (·01 sq. in.) in cross-section.

The chief feature about the line is undoubtedly the simple and convenient system hit upon for making the contact with the overhead wires. Contact is made by means of a steel arm of T shape. The breadth of the arm is about the same as that of the tram, and the arrangement has a very neat appearance. The tram runs with the upper part of the arm lagging a little behind and pressing up on to the wire. When the tram reaches a terminus, the arm will therefore be leaning towards the direction in which the tram is going next; and at starting, the friction against the wire tends to keep the arm back, and the car gliding under the arm, forces the wire upwards for a moment until the arm is in the right direction for the return journey. The arm is kept pressed against the wire by the action of two spiral springs fixed on the axis of the T piece, and also by the weight of the rod frame, the centre of gravity of which is below the horizontal axis. The arm occasionally jumps for an instant away from the wire at the joints. But, as the greatest current used is not more than 40 amperes, the sparking is not very formidable, and could have been cured

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almost entirely by the use of two arms such as were used on the cars made by this firm for the tramway at Lichterfelde, an illustration of one of which is here given (Fig. 1). The arms in this case, however, though similar in principle, are of a different and perhaps less elegant form.

It may possibly be thought that the contact cross bar of the arm here described would soon wear away; but this has not been found to be the case. It is found that sidings do not offer the least trouble as far as the overhead contact is concerned.

age speed of $8\frac{2}{11}$ miles an hour; the car is, however, always slowed down at sidings and at the sharp curve.

In addition to the two cars working with the current from overhead, there is also a larger car driven by accumulators. This is built to carry 40 passengers, including three standing on either platform. The car is provided with two motors of 10 H.P. each.

The accumulator battery consists of 162 cells of the Tudor type. Hardened india-rubber boxes are used. Whilst being

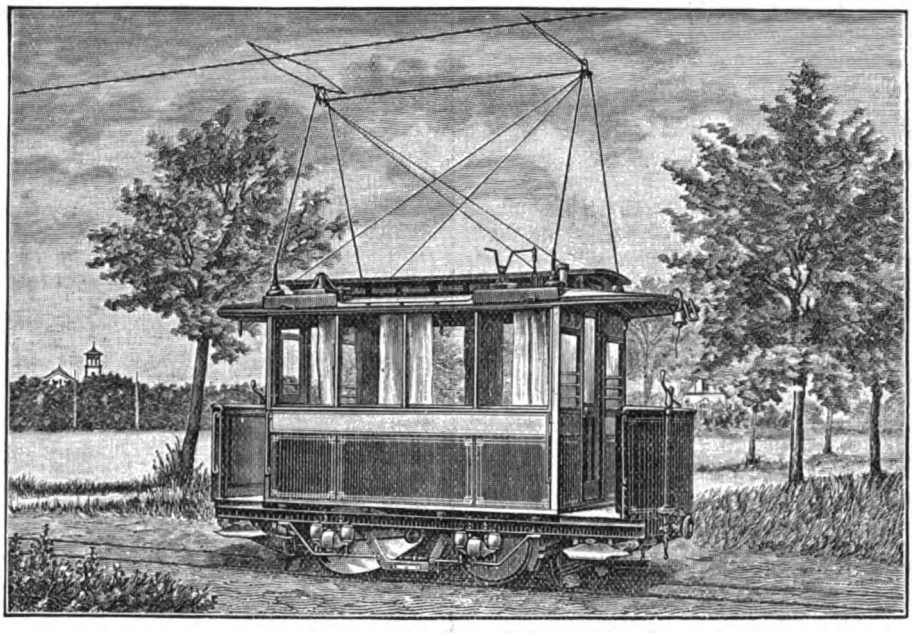

FIG. 1.—Siemens and Halske's System of Overhead Wire Electric Cars. (Lichterfelde line.)

The motor used is a 16 H.P. series wound drum machine; it drives one of the wheel axes by means of endless chains and toothed wheels (Fig. 2). The case containing the motor rests entirely on bearings on the two axes. There are two bearings for the motor on the driven axis, so that this cannot turn in a horizontal direction without carrying the motor with it; on the other axis, however, there is only one bearing for the motor, but that allows the axis to turn in all directions with the motor, and therefore with the other axis, thus allowing

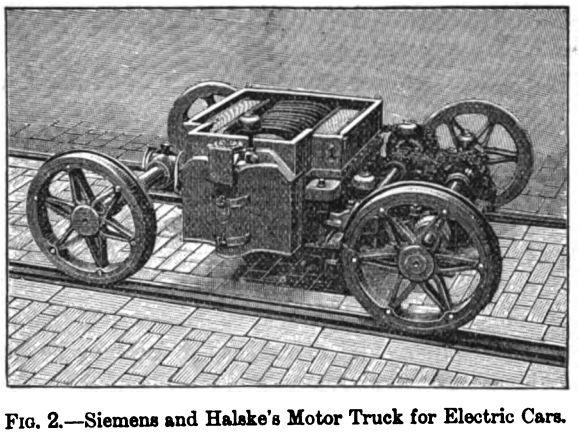

FIG. 2.—Siemens and Halske's Motor Truck for Electric Cars.

the car to round sharp curves. The motor and chains are cased in to keep out the dust and dirt, but the commutator and oil cups are easily accessible. The brushes used are dense coppered carbons, and are pressed perpendicularly against the commutator by spiral springs. The commutator has steel segments. The brushes are very broad, and a little thicker than the usual copper brushes, and require changing about every three days.

Resistance coils, to allow of the current being gradually switched on and off, are provided. The total weight of each of the cars is about 3 tons 3 cwt., and they will carry 30 persons. The 1,440 yards journey occupies about six minutes, an aver-

charged the cells are arranged in frames, which can be raised to any height required, and the substitution of the discharged for the charged cells is accomplished in a very short space of time. The speed is regulated by varying the grouping of the cells. At the station there is a turntable driven by an electric motor. The flywheel from the motor transmits the power on

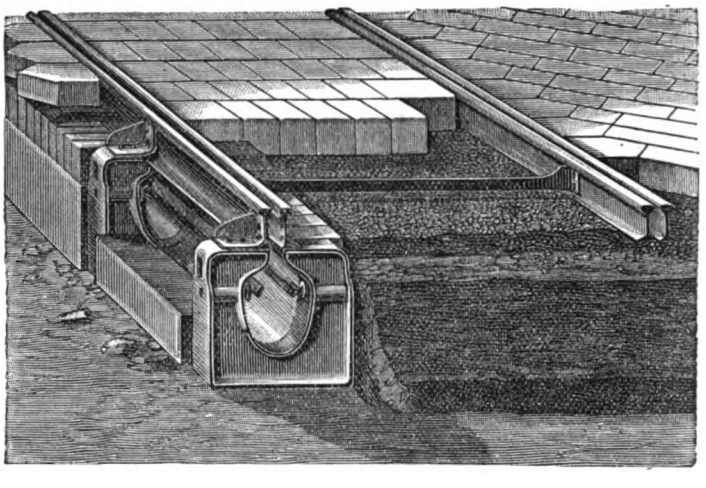

FIG. 3.—Type of Track laid down at Budapest.

to a friction wheel placed at right angles to it, and thence to the turntable wheels, or to a rope, to pull the car on to the turntable according to the wish of the driver.

The firm of Siemens and Halske, in addition to the overhead wire and accumulator traction exhibits, also show 25 yards of the type of track used for the street railway at Budapest. Fig. (3) shows the trench for the two insulated cables. This line was begun in 1889, and the projected length is 24 miles, of which nearly six miles are in operation at the present time. The number of cars running is 29, with eight as reserve. It may be mentioned that the total distance run by the trams on this line from Jan. 1st to Oct. 31, 1890, slightly exceeded 365,000 miles.

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The Electrician.

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PIONEERS OF SCIENCE.

It seems to us scarcely less than providential that, lying ready at hand for those whose minds must by the unfortunate necessity of existing, perforce be in daily contact with the dry facts of physical science and modern engineering, there should be an inexhaustible stock of subjects which may be discussed at any length and at any moment in the appropriate technical journals, without drawing too largely upon cerebral reserves and with the pleasing certainty that no inconvenient fact can be brought forward to upset a pet theory. Without this mental safety-valve we feel sure that psychology, psychography, psychomancy, and similar heterodoxies, would prove even more fascinating to those of the orthodox fold than is at present the case. A few months ago the readers of *The Electrician* enjoyed an intellectual treat of this description. A discussion, which with a little judicious encouragement might well have been still raging, was started in these columns, the subject-matter being the mode in which energy is transferred in the case of an electric circuit. There was a

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doughty champion for the longitudinal transfer, and an equally formidable one for the lateral transfer; but as there was admittedly nothing conclusive on either side in the nature of experimental proof or disproof each disputant emerged from the fray confident that he had "smashed, pulverised, and destroyed" his opponent. Like all similar discussions, this particular one probably convinced nobody who was not convinced already; but, at any rate, it may possibly have caused many who take their beliefs ready-made to pause, and may have determined others to hunt down the *experimentum crucis* which shall prove beyond all reasonable doubt the truth of the present orthodox creed. We are afraid, however, that the same moderate claim for utility cannot be made good for the discussion which periodically breaks out as to the relative merits of the theoretical and practical man, nor for those vain but ever-recurring attempts to find the equation for the average market value of the mathematician. It is, therefore, with a more than usually overwhelming sense of the responsibility incurred that we put forth a few discursive remarks as to who may and who may not be deemed entitled to the honourable appellation of "pioneer."

In this as in things more serious the different meanings which different persons attach to the same word is responsible for most of the apparent difference of opinion. No fair-minded scientist, certainly no "sound and reliable journal," would willingly and wittingly belittle a pioneer. But there have been pioneers and pioneers; and in the case of electrical engineering the word has unfortunately gained a decidedly sinister meaning when used in connection with electric lighting, so that those who wish well to the industry might be forgiven if they still exhibit a little dislike of the name and a little distrust of pioneering enterprises of all sorts and descriptions. However, be that as it may, there can be no two opinions as to the value of and praise due to a scientific or engineering pioneer when we take the word in its plain-English dictionary sense of "one who goes before to prepare or clear the way, or remove obstructions for another." All honour to the man who without hope of fee or reward quietly devotes his life to the elucidation of some obscure phenomenon, leaving it to others to reduce his results to practice, content himself to have added one rung to the ladder of human knowledge. Honour in almost equal degree also to the practical engineer, who, often with but faint hope of pecuniary recompense, undertakes to evolve a science out of a chaos of empirical formulæ or to revolutionize existing methods and machinery.

The intellectual and physical equipment of a successful pioneer of science must obviously be of no mean order. It is not everyone who is capable of marching in the van of science, clearing the way. A would-be pioneer must have an objective point, and a tolerably clear idea of the general trend of the path towards it. Blind groping after indefinite objects is not pioneering, and leads to mere confusion in the mind of the unhappy wanderer himself, and, if he be of some scientific repute, to the piling up of obstructions in the face of those who come after him which it requires a genuine pioneer to remove. Many investigators, especially in the past, appear to have taken a malicious delight in rendering their results difficult to decipher, some even going so far as to deliberately hide them from the public gaze. The faculty of stating a problem concisely, of describing experiments clearly, and of drawing correct deductions, may be deemed the second *sine quâ non* of the pioneer. Some men are, moreover, peculiarly happy both in the time and mode of publishing their results. While one seizes the psychological moment and falls quite naturally into the current style, another makes known the valuable outcome of his labours when interest in the subject has flagged, and in a manner calculated to arouse antagonism. A scientific mind, a scientific imagination, a scientific scepticism are one and all essentials. Indeed, the bare enumeration of the qualifications necessary for the part would result in a list longer than the one that includes all the arts and sciences which no self-respecting electrical engineer can afford to neglect.

Last, but by no means least, the pioneer will be all the better equipped for his task if he be of the order Pachydermata. "It were good, therefore," says Bacon, "that men in their innovations would follow the example of time itself; which, indeed, innovateth greatly but quietly, and by degrees scarce to be perceived." Now, this is plainly the course which should be pursued by the ideal pioneer; but it is naturally one which does not, as a rule, commend itself to that gentleman in the flesh, hence he not unfrequently gathers unto himself the usual harvest of those who devise or discover "new things that piece not so well; though they help by their utility, yet they trouble by their inconformity." The attitude of doubt and caution usually encountered acts, it must not be forgotten, as an active deterrent to impostors, and is sometimes fatal to wild-cat schemes; and provided it be honest it may be taken as coming in the regular day's work of the pioneer.

THE DETERMINATION OF CURRENTS IN ABSOLUTE ELECTRO-MAGNETIC MEASURE.

BY G. F. C. SEARLE, M.A.

(*Continued from page 628.*)

§ 21. **Equivalence of a Current and a Magnetic Shell.**—It has been found by experiment (first in 1820 by H. C. Oersted, of Copenhagen) that an electric current possesses magnetic properties. Thus a small magnet placed close to a wire carrying a current tends to place itself at right angles to the wire. The question at once arose as to whether a current would be acted on by a magnet, and whether one current would exert a force upon another. These questions were settled by the experiments of Ampère. He found that a magnet acts on the current, and that the direction of these actions was consistent with the principle of the equality of action and reaction. Ampère also discovered the action of one current upon another. We may conclude, therefore, that the space surrounding an electric current is a field of magnetic force just as much as the space round a magnetised body.

It follows alike from the fundamental experiments of Ampère and the elaborate researches of Weber that a current flowing in a small plane closed circuit acts and is acted on magnetically, exactly like a small magnet placed perpendicular to its plane, with its centre at some point within it, the magnet having a suitable magnetic moment, and having its axis pointing one way or the other, according to the direction of the current. A "small" magnet or circuit means one whose greatest dimensions are very small compared with the distances of magnets, or of other circuits from the one considered. The positive direction of the current is taken to be from the copper to the zinc in the external circuit of a Daniell's cell. We can now specify the proper direction of the magnet. The direction of South pole to North pole of the magnet is related to the direction of the current round the circuit, in the same way as the motions of translation and rotation in the case of a right-handed screw working in a fixed nut. Ampère also found that equal currents flowing very close together, and in opposite directions, exactly neutralise each other's magnetic effect.

§ 22. Consider now any finite linear conductor A B C (Fig. 22) carrying a current. Is it possible to replace it, as far as its magnetic effects are concerned, by a purely magnetic system,

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and if so, what is the character of that system? The following line of argument, due to Ampère, will lead to a decision on both of these points. Construct *any* unclosed surface having A B C for its bounding edge, and on this surface draw a network of lines dividing it into meshes, as *a b c d*, so small that they may be considered plane. This condition will be satisfied when the dimensions of any mesh are very small compared with the two principal radii of curvature of the surface in the neighbourhood of the mesh. Suppose that currents all of equal strength circulate in all the meshes in the same direction, A B C. The current in each of these meshes may be replaced, as far as its magnetic effect is concerned, by a "small" magnet of proper magnetic moment placed with its axis perpendicular to the plane of the mesh, and with its centre at some point within it (*see* § 21). But in all the lines of the network, except those which form parts of the actual conductor, A B C, there flow equal and opposite currents. Hence, by the experiment of Ampère, mentioned in § 21, it follows that the magnetic effect of all the currents in the subsidiary circuits is zero, so that the magnetic effect of the whole hypothetical system is reduced to that due to the current in the actual conductor, A B C. We see now that the magnetic action of the current in A B C can be mimicked by studding any unclosed surface bounded by A B C with a very large number of "small" magnets, all with their axes perpendicular to the surface, their magnetic moments and method of distribution being as yet undetermined. For any given surface the magnetic force produced by the two systems is exactly the same at all points, which are at a distance from the surface great compared with the

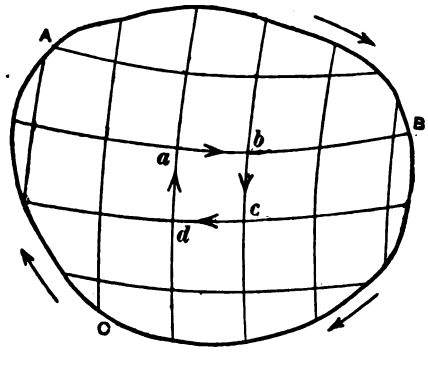

Fig. 22.

dimensions of the magnets. We shall, however, be able to get rid of this difficulty. We have now answered the first part of our question in the affirmative. Applying the same artifice as above to any "small" plane circuit carrying a current, it is easily seen that the magnetic moment of the magnet, by which for a given strength of current it can be replaced, is proportional to the area of the circuit. For, suppose that the circuit is fitted with a diaphragm of paper divided into very small squares, such as "millimetre paper;" a very large number of the squares will be included, and there will be besides a number of partly curvilinear figures where the rulings meet the bounding curve. Let currents all of the same strength circulate in the same direction in all the meshes so formed. The whole diaphragm being "small," the magnetic effect of each square at any distant point is the same, and all the squares can be replaced by magnets of equal moments. The number of squares being proportional to the area of the circuit, it follows that the magnetic moment of a "small" plane circuit for a current of given strength is proportional to its area. We have left out of account the effect of the small curvilinear figures; but when the distance between successive rulings is very small compared with the dimensions of the circuit, the number of such figures is very small compared with the number of the squares, and their effect may be neglected in comparison with that of the squares. Any difficulties which arise on this point belong purely to the Differential Calculus. Returning now to the first part of this paragraph, we see that the magnetic moment of any of the small magnets must be proportional to the area of the mesh which it is to replace. But in a uniform magnetic shell the magnetic moment of any portion is proportional to the area of that portion, so that if we make the surface, by which we filled in the conducting circuit A B C, become a uniform magnetic shell of suitable strength, we shall have obtained a magnetic system which will produce the same magnetic effects as the electric current at all points exterior to the magnetic shell itself. But as the magnetic shell may be supposed infinitely thin, practically no part of the space in the neighbourhood of the current is excluded by this proviso.

Thus a current flowing in a linear circuit of any form can, as far as its magnetic effects are concerned, be replaced by a uniform magnetic shell, of suitable strength, bounded by the circuit, but otherwise of any shape whatever, the direction in which the North side faces being related to the direction of the current in the same way as the translation and rotation of a right-handed screw. This is a most remarkable result on account of its great generality. There is scarcely any other theorem in the whole of physics which depends less upon the shape of the pieces of matter involved than does this present one. This theorem, when properly interpreted (see § 24 below), constitutes one of the two fundamental laws of electro-magnetism, the other being the theorem which expresses Faraday's discovery of the induction of currents. We shall make use of the result of this paragraph to give the electro-magnetic definition of the strength of a current. In doing so we must bear in mind the choice we made in § 3, that we would work upon a system involving the smallest possible number of numerical factors.

§ 23. **The Strength of an Electric Current** is equal to the strength, or magnetic moment per square centimetre, of the magnetic shell by which it can be replaced. Thus the unit current is such that it can be replaced by a magnetic shell of unit strength, having the conducting circuit for its boundary. This is the proper definition of strength of current in electro-magnetic measure. A definition of the strength of a current is often given in terms which involve the action of an element of current (*i.e.*, a short piece of the current having a beginning and an end); but since we can know nothing for certain concerning the properties which an element of a current completely separated from a circuit would possess (all currents in nature flowing in closed circuits), it is much better to define the strength of a current in terms of the properties of a closed circuit. We shall show later how the definition involving an element of current may be derived from the present definition. For the future, we shall consider that all the currents we are dealing with are measured in terms of the electro-magnetic unit as defined above. Partly because the electro-magnetic unit is rather large, and partly on account of the magnitudes of the ohm and the volt, it has been found to be convenient to take as the *practical unit* of current the ampere which is defined to be one-tenth of the electro-magnetic unit. The ampere is NOT, at least in theory, the current which deposits so many grammes of copper or silver per hour in an electrolytic cell. The idea that the electrolytic method is the proper way of defining current strength is rather surprisingly prevalent among students. The ideas involved in the measurement of a current by electrolysis are, no doubt, very much easier than those depending upon magnetic shells, solid angles, 4π, and other recondite matters, but nevertheless they are not theoretically accurate. Another class of people fall into an error very much worse than the one above, and state that an ampere is the current which an E.M.F. of one volt will send through one ohm. This has no doubt arisen from the widespread use of resistance boxes, and of batteries whose E.M.F.'s are given in tables as so many volts. These people forget entirely the methods which have been employed in the determination of the values of the ohm and the volt; in fact, the electro-magnetic definition of the ampere is employed in the evaluation of both the ohm and the volt.

§ 24. **Magnetic Potential due to a Current.**—Being now able to replace a current by a magnetic shell of the same strength we can at once write down the magnetic potential at any point P due to a current of strength i flowing in any circuit. It is simply $V = i\,\Omega$, where Ω is the solid angle subtended at P by the circuit, Ω being taken with the proper sign. The sign may be determined by the specification given in § 21, or by means of the following, which is easily seen to be equivalent to it. The solid angle is to be reckoned positive

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when the current, as seen from P, appears to circulate in the opposite direction to that of the hands of a watch looked at from the front.

Return now to § 19. Take any closed curve P A B Q, Fig. 23, P and Q being indefinitely close together. We proved that the work done by external agencies in taking a unit pole from P to Q by the path P A B Q was zero when there was no part of the magnetic shell between P and Q, *i.e.*, when the path P A B Q could be continuously transformed into the straight line P Q without cutting through the edge of the shell. But if a part of the shell were between P and Q so that the path PABQ could not be transformed into the straight line P Q without cutting through the edge of the shell, then the work done was $-4\pi i$ where i is the strength of the shell. In the same way, if we draw any curve not linked with an electric current, then the work done in taking a unit pole from any point on the curve all round the curve and back to the starting-point is zero. If the curve *is linked* with the electric current then taking two very near points on it and drawing the equivalent shell so as to pass between them, the work done in the path P A B Q is $-4\pi i$, P being on the North side of the equivalent shell. In the case of the magnetic shell the work done in taking the pole along the straight line Q P is $+4\pi i$, but in the case of the current is zero, since there is now no peculiarity about the short path Q P, as in the case of the shell. Thus, when a unit pole is taken completely round a closed curve which is linked with the current, $4\pi i$ ergs of work are done. By referring back to §§ 19, 21, we can see that the work spent on the magnetic pole by external agencies is positive when the relation between its motion round the

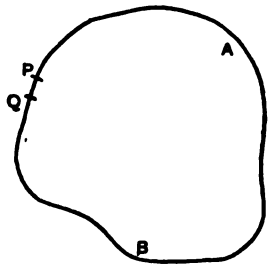

Fig. 23.

curve, and the direction of the current with which the curve is linked is the opposite to that between the rotation and translation of a right-handed screw.

It must be carefully noticed that there is an important distinction between the magnetic potential due to any system of magnets and that due to a current. The potential due to the system of magnets is single-valued, *i.e*, by whatever path we bring the unit testing pole from any fixed starting point to any given point, the work spent upon the pole is always the same. But in the case of the current the potential is many-valued, and for a single linear circuit should strictly be written $V = i\Omega + 4\pi n i$, where n may be any integer, and is the number of times that the path of the moving pole has twined itself round the electric current. See also § 13.

On account of the extreme importance of the result of § 22, and of this present article, it is not surprising that attempts have been made to obtain this result, or results equivalent to it, by different lines of reasoning. Thus M. H. Poincarè in his recent work "Électricité et Optique," Ch. VII., gives a method which depends upon some of Ampère's experiments and upon the *assumption* that the magnetic force at any point near a current can be derived from a magnetic potential just as in the case of a magnet. The method is one of considerable elegance. Again, in the treatise of Mascart and Joubert, Vol. I., Part IV., Ch. I., a method is given, based upon the "law of Biot and Savart," that the magnetic force due to a very long straight current is inversely proportional to the distance from the current. The method is ingenious, but unfortunately in § 447 (English edition) an *assumption* is made which appears justifiable only on the ground that it brings out the correct result.

(To be continued.)

POST-OFFICE TELEGRAPHIC COMMUNICATION WITH THE CONTINENT.

Last week the transfer of the telegraphic communication with the Continent from the offices of the old Submarine Company to the General Post Office was completed ; the premises in Throgmorton-avenue have been vacated, and more than two hundred operators have been added to the large staff at St. Martin's-le-Grand. For the last two and a-half years the work has been under the control of the Post Office, and a number of new cables have been laid and many important through connections have been established.

Fifty-two distinct lines are connected to the large hall, which has been devoted to foreign cable work, besides the four lines of the Paris-telephone cable, which can, if required, be used for telegraph purposes. Hughes' printing instruments are employed, since these are in general use on the Continent. Improvements will probably be introduced, such as an electrical arrangement for driving, in place of the pedal for winding up the weight, and experiments are being made in duplexing. The Hughes' instrument is not a slow one, as is generally imagined, for 700 messages have been sent in the day direct to Vienna, and as many as 80 have been sent in an hour.

One side of the hall is occupied by instruments working on the French cables, and the other by the German, Dutch, and Belgian lines. The through line to Vienna takes the messages for Austria, Hungary, Bulgaria, &c., while the traffic for Constantinople passes through Rome. These direct lines effect a very important saving in time and accuracy of transmission. Another valuable improvement which has recently been arranged is the direct communication between Liverpool and the Continent. Near the entrance to the hall is a table with relays, allowing communication between Liverpool and Havre, but the translating instruments on an adjoining table for Liverpool and Amsterdam were not being used on the occasion of our visit, the lines being connected through on the terminal board, messages being sent at about 100 per hour by this route. Five distinct wires go to Berlin, the instruments being all grouped together.

A double lift nearer the middle of the hall is in communication with the pneumatic despatch service, and the incoming and outgoing messages pass through the hands of clerks at neighbouring tables, where they are distributed to or received from the instruments. A special pneumatic service is laid on direct to this hall from the Stock Exchange, thus avoiding even the short delay caused by the use of the lift. The new land lines and the new cable to Germany are fully occupied ; and these, together with many improvements in working, have enabled the Post Office to keep pace with the large increase of traffic which has been brought about by the reduction in charges for foreign telegrams.

LITHANODE BATTERIES.

Lithanode is familiar by name to many of our readers, but although it has been talked about on various occasions for several years past little attempt has been made until lately to place it on the market. We recently visited the works of the Mining and General Electric Lamp Company at Millbank and Westminster, where various forms of plates and portable lamps are manufactured.

It is generally known that lithanode plates are composed of a compressed powder, and since they consist mainly of peroxide of lead it has been assumed that this material is used in their manufacture. This is, however, not the case, for a plate made by compressing peroxide of lead with however great force will disintegrate when it is wetted. The process which we saw in operation is very simple. A weighed quantity of litharge is mixed on a slab with a measured quantity of sulphate of ammonia in solution. The paste is well kneaded, and, having been placed in a metal gauge, between pieces of canvas, is subjected to a heavy pressure by hydraulic presses. Seven or eight of these presses are employed in the mixing room. The plates thus made vary

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in size from 3½in. by 3⅛in. up to 7in. by 4in., and the thickness varies from ⅛in. to $\frac{3}{16}$in. On leaving the moulds the plates are allowed to dry very slowly for about a week, during which period they "set." They are then "formed" in a bath of sulphate of magnesia, a current being passed through them to peroxidize the lead. The process is conducted at a low-current density, and is completed in about two days. They are then dried again in a warm drying-room fitted with racks, where a considerable number of plates are stored. A dense plate of peroxide is thus produced, thoroughly homogeneous, very hard, and having a ring when struck. Softer and porous qualities are made for purposes where a rapid discharge is required.

At first, some difficulty was experienced in avoiding local action, for while the lithanode plate itself is quite free from any trouble of this kind a connection of some kind has to be made with the terminals, and it is necessary that the contact should be good, the resistance low, and that no oxidization should take place. Platinum was used at first, but now a strip of gilded lead is used, which gives an excellent contact, and is not attacked during work or while the battery is standing.

Another common misconception has been that lithanode plates are intended only for use in primary batteries. It is true that a lithanode-zinc couple will give nearly 2·5 volts, but, as is usual in nearly all primary batteries, it runs down on discharge, though there is no consumption when the circuit is open. A high-resistance lithanode-zinc cell is made for telephones, bells, &c., and a low-resistance pattern for running small lamps for telescopic and microscopic use, and for illuminating the sights of guns or clock dials. When used as a secondary battery in conjunction with spongy lead, it gives two volts. The electrolyte used is sulphuric acid, diluted to a density of 1·220. The battery should not be run down below 1·8 volt, and it will be found to maintain its voltage as steadily as a good secondary battery. A "capacity" of one ampere hour per ounce avoirdupois of lithanode may be obtained. Several patterns of hand lamps are made, and an order for 600 miners' lamps is being executed for a French colliery. The miner's lamp consists of a two-cell battery mounted in a sheet steel case, and wedged therein by india-rubber blocks. Safety devices are arranged to prevent short-circuiting of the terminals. Portable reading lamps and very compact testing cells, weighing 3oz. and yielding one ampere hour, are among the many patterns which have been made up.

THE GÜLCHER THERMOPILE.

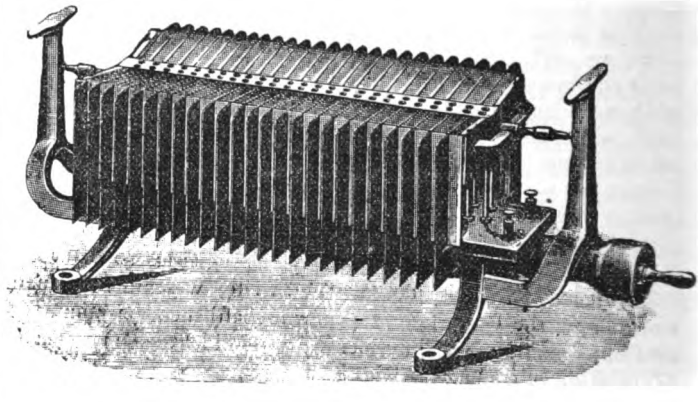
The Gülcher thermopile attracted a good deal of attention at the Frankfort Exhibition, and not only have contradictory figures been given as to its performance but conflicting views are held as to the theoretical efficiency. The practical value of the present form of thermopile may be judged from the figures given, but comparison with a dynamo is unnecessarily severe, and we only make it because the inventor invites such comparison. It seems very probable that well-constructed thermopiles may be used in many cases in place of primary batteries. The range of application of primary batteries is well known to electrical engineers, and, as far as electric light is concerned, they are of little practical use on a larger scale than the running of a five candle-power lamp.

The following account of the thermopile is abstracted from the official journal of the Frankfort Exhibition :—

This thermopile presents a new solution of the interesting but difficult problem of producing electric energy directly from heat. As hitherto constructed these apparatus have never been found of any practical use, owing partly to their short life and partly to their very low efficiency. Herr Gülcher's lately patented thermopile, however, not only does away with these defects, but appears to be capable of competing with the dynamo.

The piles exhibited are constructed for heating by gas, and are so arranged that overheating is rendered impossible, and, consequently, the pressure regulator (up to now a necessary appendage) is done away with. For comparison with the new type an old form of the apparatus is also shown. In the latter, six small gas flames burn outside each negative electrode (formed of a nickel tube) ; in the new form only one flame is used for each electrode, and this is placed inside the tube. If the pressure in the gas mains is increased, the only result is that these Bunsen flames become longer, and the extra length being beyond the extremities of the tubes the effect, so far as heating the latter is concerned, remains unaltered. As soon as the flames are lighted the apparatus requires no further attention. After about seven to ten minutes it is fully heated, and from that time the E.M.F. remains constant, however the gas pressure may vary. The accompanying illustration shows the larger of the two forms in which the apparatus is manufactured for burning gas by Messrs. J. Pintsch and Co., of Berlin. The figure is one-sixth of the full size. The weight is about 10 kilogrammes, and the number of elements 50 : these are placed in two parallel rows on a slate bed, which forms the top of the gasholder. Each element, as already mentioned, consists of a small nickel tube, in which is placed a "one-hole" soapstone burner. A connecting piece of nickel is soldered to this tube, and is connected to the prism-shaped positive electrode, formed of an infusible antimony alloy. In order to prevent any mechanical change, such as fissures, occurring in this alloy, and so changing the internal resistance, two steel rings are placed round the connecting tube. At the outer extremities of the positive electrodes are placed cooling pieces of copper, which also serve to form the connections. The elements are insulated from one another by means of asbestos. The larger of the two forms gives 4 volts. The internal resistance being 0·4 ohm, the pile is capable of giving a current of 5 amperes on a circuit possessing the same resistance. The smaller pile contains 25 elements, and supplies the same current at half the volts. The consumptions of gas are 200 and 100 litres per hour respectively, the cost being about ·36 and ·18 of a penny.

It will thus be seen that these piles are well adapted for the electro-deposition of metals, and also for charging accumulators arranged in parallel. With the help of the latter they are very useful for telegraphic purposes, and can also be applied to running small electric light installations.



In reply to our enquiries, we have received a letter from Herr Gülcher, of which the following is an extract. :—

"I mention that the results obtained from the thermopiles vary slightly, owing to some little differences in the composition of the alloy of antimony employed for the positive electrodes, the casting of which offers some difficulties. The figures given in the report are the average results of a number of thermopiles lately constructed.

"In order to show you how the results have been obtained I will give you an example from my test-book.

"*Date, October* 9, 1891.—Pile No. 98 ; number of elements in the pile, 50 ; gas consumed per hour during the test, 190 litres ; E.M.F. measured by a Siemens torsion-galvanometer of a resistance of 1,000 ohms, 3·8 volts ; difference of potential at the terminals with an external resistance of 0·5 ohm, 2·11 volts. Current during the last test, 4·22 amperes. Calculated from these figures you obtain : The internal resistance of the pile when hot and on full load, $(3{\cdot}80 - 2{\cdot}11)/4{\cdot}22 = 0{\cdot}41$ ohm. The current in an external circuit of equal resistance (0·41 ohm), $3{\cdot}8/2 \times {\cdot}41 = 4{\cdot}634$ amperes. Therefore, the total power of the pile $= 4{\cdot}634 \times 3{\cdot}8 = 17{\cdot}61$ watts with 190 litres or 92·7 watts per 1 cubic metre of gas ; and the maximum available effective power of the pile = 8·805 watts with 190 litres or 46·34 watts per 1 cubic metre of gas.

"There are now three sizes of these small piles being constructed, which differ only in the number of elements according to their purpose, viz., 26, 50 and 66 elements. The latter is especially constructed for charging accumulators, and has an E.M.F. of 4·6 to 5·2 volts, so that during charging it will work

with its full effective power at a difference of potential of 2·3 to 2·6 volts.

The experiments with the large piles, which are to be heated by coke burned in a "generator" stove, have not yet been concluded. The figures given in the report refer to a pile of 16 rows of 80 elements each—that is, 1,280 elements together. In the first four or six rows (nearest to the source of heat) the E.M.F. of each element was about 0·08 volt, whereas in the last row (the farthest from the source of heat) it was only 0·04 to 0·045 volt; the latter elements, however, were of double the height of the first ones, so that their internal resistance was only half the one of the elements in the first rows, and, therefore, all the elements, the first as well as the last, gave the same current, viz., about 10 amperes.

From the measurement taken at that first pile, which has been tested for three months, I place the following ones of two single elements of the first and last row at your disposal:—

Date of measurement, October 20, 1890:—I. An element of the first row: E.M.F. with an external resistance of 100 ohms (a Siemens torsion galvanometer), ·078 volt; difference of potential with an external resistance of ·003 ohm, ·034 volt; intensity of current during the last test, 11·33 amperes. Therefore, internal resistance of the element = (·078 − ·034)/11·33 = ·0039 ohm; and the current for the maximum effective power, ·078/2 × ·0039 = 10 amperes. II. An element of the last row:—E.M.F. with an external resistance of 100 ohms (Siemens torsion galvanometer), ·044 volt; difference of potential, with an external resistance of ·002 ohm, ·021 volt; current during the last test, 10·5 amperes. Therefore, internal resistance of the element = (·044 − ·021)/10·5 = ·0022 ohm; and the current for the maximum effective power ·044/2 × ·0022 = 10 amperes.

The theoretical reasons you mention lead to discouraging results only when based on the old principles of thermo-electric piles. If, however, my present improvements and the still further probable developments thereon be taken into consideration, we arrive at quite different results. In fact, if the price of a thermopile had not to be considered in competing favourably with other generators of electricity, I should already be able, with the present improvements, to construct a thermopile of the same efficiency as that of a dynamo-electric machine driven by a steam engine, calculating this efficiency from the energy stored in coal."

In the concluding portion of this extract Herr Gülcher desires to draw a comparison between his thermopile and a steam engine consuming coal; but we have no information as to the coal required for working the thermopile. As we pointed out on a recent occasion, the cost of gas for a gas engine, and of coal for a steam engine of the same power, differ but very little when the consumption per day or per year is taken, although the cost of fuel per horse-power hour by a gas engine is about five times that of a steam engine. We are inclined to base our estimate rather on the cost of the fuel than on the theoretical quantity of energy contained therein. A steam engine, we know, only returns about one-thirteenth of the energy of the coal, and most of the loss occurs on the boiler side of the slide valve. A far larger proportion of energy is yielded by a gas engine; but if the cost of making the gas from the coal is taken into account, there is little to choose between them, when the load factor is no better than that of most electric supply stations. Herr Gülcher makes a comparison at first on the assumption that *gas* is used for heating the apparatus. Now, 23 cubic feet of gas will yield one horse-power hour in a gas engine; and taking the low combined efficiency of 75 per cent., we have to consume about 40 cubic feet for one kilowatt hour, say 1·2 cubic metres. But the thermopile exhibited at Frankfort consumes 21·6 cubic metres, or about eighteen times as much as a gas engine and dynamo.

The difficulties which have to be encountered by a thermopile are numerous. A small current density must be employed, or the C^2 R will warm the cool junctions. The elements must be metallic, and even if some other substances could be found, they must be good conductors of current, and therefore good conductors of heat. But this makes it difficult to maintain a considerable difference of temperature, and if the cooling by water be attempted a new difficulty of a mechanical nature arises. Severe stresses are set up, and thermo-electric metals being generally brittle, the pile will pull itself to pieces, while there is at the same time a temptation to push the temperature of the hot junctions to a degree not far from their melting point. Solder cannot then be relied upon, and mere screwed up joints are sure to offer considerable resistance under these unfavourable conditions.

For these reasons, and for the economy of heat, a thermopile will only work satisfactorily on a good load factor. It should be applied to continuous work, and will probably suffer far more wear and tear during warming up and cooling down than during a long run of work. The waste of heat in firing up may be compared to that of a boiler or a blast furnace.

The very current which it generates acts antagonistically to the heat of the furnace in virtue of the Peltier effect, which tends to cool the hot junction. But on closer examination this need not constitute a defect, but may be compared to the back-electromotive force of a motor. A good thermopile when it is working will strongly tend to cool the heated junctions and to heat the cooled. It ought to be quite safe to subject a thermopile when at work to temperatures that would ruin it if it were left on open circuit, there being a very close analogy with a motor, which can not only stand, but efficiently utilise a voltage which would burn out the armature coils if it could not run. From one point of view, the back volts of a motor are the essence of its efficiency, since if they were non-existent, a large current would pass. The practical issue of this point is well enough understood, however curiously the problem may be stated, and such as it is it applies by analogy to the cooling of the heated junctions. But it is essential that the cool junctions be kept cool; and here are three causes tending to warm them, conduction, C^2 R, and the Peltier effect. It is not therefore clear why, according to some authorities, the Peltier effect is advantageous rather than otherwise.

The little Clamond piles for laboratory purposes, with an output equivalent to a Leclanché cell, are seldom worth working, but the Hughes instruments of the Submarine Company were thus supplied with current for the lines between London and Paris for some time. A number of ingenious uses have been suggested; it has been proposed to use the cooling Peltier effect for refrigeration, by the continual abstraction of heat. We heard a proposition a few days ago for helping up the pressure at the end of a long feeder. It was suggested that a thermopile should be put in series with the feeder, and warmed up by a shunt coil, but it need hardly be said that the suggestion was not a serious one.

One of the best primary batteries on the market might under very favourable circumstances give an electrical unit for 1s. 6d., but at a great trouble and nuisance in the handling of many gallons of chemicals. A price of about 3s. or 4s. a unit may be taken for ordinary batteries, and this agrees very well with the price per 1,000 "joulads" given in Mr. J. T. Sprague's "Electricity." The cost of gas per electrical unit comes to about 1½d. with an engine and dynamo, and eighteen times this is 2s. 3d. It appears, then, that although no satisfactory comparison can be made with the dynamo, the Gülcher thermopile competes well with batteries, and offers the very important advantage in that there are no chemicals to handle, jars to clean, &c.

ELECTRIC LIGHTING IN THE ITALIAN NAVY.*

BY LIEUT. A. POUCHAIN.

Ever since the year 1875 attempts have been made in the Royal Italian Navy to turn the then recent electrical discoveries to a practical use as a means of obtaining search lights. The plant first tried, *i.e.* the early Siemens and Brush dynamos, the lenticular projectors of Serrin, Siemens, and others, the apparatus of Gramme, Mangin, Reynier, Jablochkoff, and Wordermann, were found neither to satisfy the requirements nor to be of a practical nature. Meanwhile the new features introduced into naval construction, and the new machinery, daily made the

*Abstracted from the *Rivista Marittima*.

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want more felt of an improved system, which would include at the same time the running of search lights, the direction of artillery, and the efficient interior lighting of engine, ammunition, and other rooms, for which oil or gas was insufficient, unhealthy, or even dangerous.

At first one or two search-lights were considered sufficient for the safety of the ship, and therefore only two high-speed engines coupled direct to the independent generating dynamos were required. A Pacinotti Gramme dynamo, driven by a Brotherhood engine, thus served very well for the occasional use to which they were subjected, in spite of the low efficiency and high consumption of steam. But when the ships in course of time were much modified and enlarged and fitted with smaller and more numerous guns, the torpedo boats on the other hand being greatly improved and becoming more dangerous, the necessity of having several search-lights at various parts of the vessel became more apparent.

The problems to be solved were the following:—(1) to fit every ship with the smallest number of dynamos compatible with efficiency of service; (2) to choose a plant easy of control and supervision, and, above all things, durable; (3) to utilise the old material as far as possible.

In order to comply with the first condition, the Royal Navy was classified according to structure and the strategetical importance of the ships. The current required for each search-light was settled at 50 amperes; a certain number of lights was allotted to each ship, in proportion to the number of its guns, so as to ensure an alternative supply for each lamp. To the current required for this purpose was added that necessary for lighting the engine-rooms, &c.

One or more supplementary dynamos were devoted to the lighting during the day-time of the following eight ships: "Re Umberto," "Sicilia," "Sardegna," "Italia," "Lepanto," "Duilio," "Dandolo," "Lauria," "Morosini," and "Doria," on account of the numerous dark rooms existing on board these ships, owing to their special construction. The electric plant was divided into four categories, viz., dynamos of 300 amperes, 200 amperes, 150 amperes, and 100 amperes, capable of supplying simultaneously six, four, three, and two search-lights respectively, and two dynamos were considered to ensure a perfectly reliable and regular service of light during times of peace. A standard potential of 65 volts was then fixed upon for the machines.

The solution of the second problem was based upon the following considerations. Indirect-transmission engines were excluded as being too cumbersome; high-speed engines, owing to their want of economy and delicacy; and direct-coupled horizontal engines, on account of the amount of room they take up. The vertical type of engine consequently had to be adopted, and of these it was considered advisable to reject compound engines in order to be able to make use of steam from the ship's boilers, the pressure in which did not exceed 45lbs. per square inch.

As regards dynamos the continuous-current system was preferred. Pacinotti-Gramme ring armatures were rejected on account of the powerful reactions occurring in them; and drum armatures were objected to on account of the difficulty of ventilating them, a most important point in view of the high temperatures in the rooms on board the ships. The flat Schuckert-Mordey ring was therefore adopted; and finally, to avoid the use of large polar masses, the four-pole system was chosen. These, with an engine of one or two cylinders, thus formed the plant adopted. The dynamos were compounded to give a constant potential of 65 volts.

In order to satisfy the third condition and utilise the old plant, consisting of Pacinotti-Gramme machines and Brotherhood engines, the fields of the dynamos were re-arranged, so that they could be excited at will either by shunt or series coils, giving, in the first case, 30 amperes at 65 volts for interior lighting, and in the second, 50 amperes at 50 volts for working the search lights, and these generators were assigned to ships of minor importance. The selection of engines and dynamos was a great step towards the completion of the task; but projectors, lamps, and fittings had still to be decided upon, and the choice of these gave rise to a second series of experiments.

Search-light Service.—The best projecting apparatus was agreed upon without difficulty, the Mangin projector having been proved by many years' experience to be the most efficient of all lenticular and parabolic apparatus. The choice of a lamp was by no means so easy to decide upon, and it was only after many unsatisfactory experiments with various types that the head electrician of the navy, Prof. Pasqualini, succeeded in bringing out a good lamp which was at once adopted.

Incandescent Lamps.—The lighting of the small rooms on board by arcs was not to be thought of, and it was decided to provide incandescent lamps which should fulfil the following conditions:—(1) Adaptability to the special features of a man-of-war; (2) sufficient lighting capacity.

Having tried the lamps of Edison, Swan, Brush, Bernstein, Khotinsky, and Cruto, in turn, and weighed the merits and demerits of each, it was decided to select Cruto's latest system with Edison's holders, and for the lamps near the large guns a special spring-holder similar to that of Pieper. The choice of this apparatus was especially happy, as it allowed all the material to be purchased in Italy.

As regards the lighting power of the lamps that of 12 candle-power was finally agreed upon as being the most suitable under the existing circumstances. Where more light than one of these gave was required, several of them were grouped together so as to preserve as far as possible one single type of lamp throughout, an arrangement which is almost essential to a satisfactory system of lighting.

Leads and Insulation.—For the sake of security, the idea of using a single circuit for all purposes was entirely put aside. Separate circuits, therefore, varying in number in different ships, were assigned to the objects of lighting, (1) machine rooms, (2) the guns and ammunition rooms, (3) the gangways and other parts of the ship which had to be illuminated in ordinary daily life, (4) the cabins, and (5) the signalling apparatus. These circuits were distinguished by characteristic numerals for those relating to internal lighting, and by letters for those devoted to running the search-lights, &c.

Finally, it was decided to exclude the use of the vessel as a return lead, both on account of the danger of getting short circuits, and because of interfering with the ships' compasses. It was also considered unnecessary to adopt the multiple wire system on account of the comparatively short length of the circuits, and the ordinary two-wire method of laying the mains was therefore settled upon. The next question to be decided was as to the use of lead-covered cables. On the "Duilio" it was found that contacts between the copper and the lead sheath were of somewhat frequent occurrence, especially at points where branches were taken off the mains. Moreover, it was found that the lead-covered cable had to be used at a lower current density owing to the increased difficulty of radiating the heat. At the same time this form of cable could be much more easily laid down than the other, and accordingly it was adopted for leads which were specially exposed to the weather, the bulk of the conductors, however, being of the ordinary kind without metallic covering, enclosed in wood casing. The sizes of cable used were calculated so as to give a maximum fall of 3 per cent., or two volts on a 65-volt circuit, at the lamps. The dynamos were insulated by being placed on teak beds, and it was found that the total insulation resistance varied between ½ and 1 megohm, a result which, if it could hardly be called good, at any rate was satisfactory taking the circumstances into account.

Safety Apparatus.—Cut-outs on mechanical principles were discarded in favour of a form of fuse adapted to use on iron ships. These fuses were divided into two classes, the first to be used for mains and suited to heavy currents, and made in two sizes, and the second for branches and small currents, made in four sizes. Both classes were used as direct fuses, as being simpler and more secure than those to work in shunt. The larger fuse wires were 50mm. in length and the smaller class 20mm. The automatic interrupters for the protection of the dynamos were adjusted so as to break the circuit if the current rose over 50 per cent. above that which any dynamo was supposed to give as a maximum output.

Distribution.—A good and simple arrangement for distribution of the current conduces in no small degree to the success

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of any installation. The number of accessory apparatus was brought down as low as possible, and all circuits were brought to a single distributing board. It was made impossible for more than one dynamo to be connected on to a single circuit by using of distributing bars of special design.

The apparatus included an ammeter and a voltmeter; the necessary lamps for testing the circuits; an automatic interrupter for each machine; a Buss tachimeter for each engine; and the regulating resistances for the search-lights. The choice of satisfactory instruments was exceedingly difficult. Most of the commercial instruments in use depend for their action either on permanent magnets or on gravity, or on both. On an iron ship at sea it is clear that neither of these actions could safely be relied on. After a very long series of tests the Déprez-Carpentier instruments were provisionally adopted, but experiments are still being carried on with the view of finding something more suitable.

Engines and Dynamos.—The electric generators adopted for use in the Italian navy included four types, viz.:—(1) an F_2 Victoria dynamo of 300 amperes, compounded to give a constant potential of 65 volts at a speed of 250 revolutions per minute, coupled by means of a Raworth coupling to a vertical two-cylinder engine, provided with an Acme governor and a Buss tachimeter; (2) an E_2 Victoria dynamo giving 200 amperes at the same pressure, the speed being 300 revolutions per minute; (3) an E_2 (bis) Victoria dynamo, giving 150 amperes at the same pressure, the speed being 300 revolutions per minute. Both these dynamos (2 and 3) were coupled in the same way as the F_2 machine to two cylinder vertical engines, and were also provided with the same governors and tachimeters; (4) a D_2 Victoria dynamo, giving 100 amperes at 65 volts at a speed of 300 revolutions. This was coupled to a single cylinder engine, the coupling, governors and tachimeters being the same as before. A single bed plate in all cases served for both engine and dynamo.

The existing plant that was utilised consisted of a Pacinotti-Gramme machine, the fields being rewound so as to be capable of being excited either as a shunt or in series at will. These machines were connected by key couplings to Brotherhood engines, and furnished with Brotherhood governors and Buss tachimeters. These generators were placed on vessels of secondary importance, and were intended to be superseded by the above-described types as soon as they were worn out.

The engines were intended to be run at pressures of 45lb. and 70lb. per square inch. The chief points of interest in connection with the engines were the Raworth coupling and the governors used. Both of these, however, are so well known as to require no description. The same is also true of the 4-pole flat ring Victoria dynamos.

(To be concluded.)

ELECTRIC MINING-MACHINERY, WITH SPECIAL REFERENCE TO THE APPLICATION OF ELECTRICITY TO COAL-CUTTING, PUMPING, AND ROCK-DRILLING.*

BY LLEWELYN B. ATKINSON AND CLAUDE W. ATKINSON, ASSOC. MM. INST. C.E.

(Concluded from page 668.)

DISCUSSION *(concluded).*

Mr. FREDERICK HURD thought the question of danger had been very much overrated. He spoke from practical experience. It was no uncommon thing for him to spend a sixteen-hours' shift in a mine day after day. He had seen machines at work and giving off sparks that would amaze some persons, in places where they had been most particularly requested to be careful; and he was quite sure that it was not possible for these sparks to cause explosions in the way referred to. In the north of England, in Cardiff, and all over the country, such machines were used; also in France, Belgium, Austria, Hungary, America, New Zealand, India, and China, in places where large volumes of gas were supposed to be constantly given off. It was impossible for the cutters to come in contact with the grit and pyrites in the coal without giving off some sparks, and there was more danger to be anticipated from the cutter than from the dynamo. Reference had been made to what might be accomplished with compressed air, but even if they could get cent. per cent. the advantages obtained would not compare with the facilities that would be procured by the introduction of wire. The large pipes necessary to convey compressed air were a source of great expense.

Mr. E. R. DOLBY remarked that various speakers had alluded to the danger of sparking in fiery mines, and Mr. Crompton had stated that he thought the risk from the sparks produced by pick-axes was almost as great as that from the sparks on the commutator of a motor. After the disastrous explosion at St. Etienne, in France, a sub-commission was appointed, consisting of three well-known gentlemen, Messrs. Mallard, Le Chatelier, and Chesneau. They had prepared fire-damp, pure C_2H_4, and let it into a wooden box from a Bunsen burner. In that way they had produced a mixture of different percentages of fire-damp and air. They then placed pieces of sandstone and porphyry near the box, and struck them with pick-axes in such a way as to cause sparks to fall into the box. The mixtures were made so that a naked light ignited them. They found that a mixture of ordinary illuminating gas and air could be ignited by sparks so produced. They then proceeded to experiment upon the fire-damp mixed with air, and they found that it could not in any case be ignited with the sparks. The pick-axes were made of mild steel with removable points, such as were used at St. Etienne, and also of iron such as were employed at the Anzin mines. Besides these they tried picks of steel with 13 per cent. of manganese, and also of aluminium bronze with 2 per cent. of silicon. The aluminium bronze picks produced no sparks, and in the whole series of experiments they never succeeded in igniting any mixture of fire-damp and air. That, he thought, was exceedingly satisfactory. It had been said that the sparks produced on the commutator never caused an explosion, and he thought it was clear from the experiments he had mentioned that sparks from pick-axes would not do so.

Mr. HOWARD D. PEARSALL said, in compressing air by water-power on the principle to which he referred, he had obtained an efficiency of 85 per cent., and if that was multiplied, as before, by the efficiency of transmission and of the secondary motors, the net efficiency to be realised at a distance of three miles was 67 per cent. Those facts were (1) that 40 per cent. efficiency could be and was attained even with no cooling, as in Paris; (2) that the absence of cooling caused a loss of 40 per cent. of the gross power; (3) that a quantity of cold water, a thousand times the weight of the air, could be used so as to produce a nearly perfect cooling. Hence 40 per cent. waste was saved.

Mr. A. P. TROTTER remarked that his only excuse for speaking was that the first two of the machines in question were among the last which he had made before withdrawing from his manufacturing business. Many arguments had been put forward against the use of the machines in coal mines, but the only experiments which had been adduced (besides those that had just been mentioned, and which were not electrical) were those of Mr. Snell, and he did not succeed in igniting a mixture of coal-gas and air by means of sparks from a machine until the commutator got seriously hot. But where the only reason for the ignition of a mixture of air and gas was the fact that the commutator got hot, it seemed that carbon brushes would not be suitable. Those who had spoken of fire-damp igniting at the machine appeared to have lost sight of the fact that with the carefully-protected cases used in the motors, the fire-damp could not suddenly produce an explosive mixture. It must leak in by degrees, and, as the authors had stated—though this had evidently escaped the attention of Prof. Forbes and others—before it could become an explosive mixture the gas would burn, if it could be ignited at all by the spark, in the same way as in a miner's lamp. When the fire-damp got into the lamp it did not suddenly become an explosive mixture; it gave warning, and when the miners retired, they need not let the coal-cutting machine continue to run; the current might be cut off at the spot, or when they came back to the main switch. It was rather disappointing that the discussion which directly challenged air-compressing engineers, had not brought out a few more figures. He had hoped that at Birmingham they had attained something better than 44 per cent. It was difficult to know, with regard to the Paris installation, how to distinguish between what they were doing and what they might do. At all events, the 44 per cent., or even 50 per cent., was an enormous encouragement to electrical engineers, for there were few cases in which they need go as low as that. The loss by transmission in cables might be put at 10 per cent. or 20 per cent., leaving an ample margin for losses in dynamos and motors. Evidently air must do a great deal more than it had yet done if it was to compete with transmission by electricity in mines or elsewhere. One interesting feature of the Paper was the application of electricity to mechanical engineering. They had all seen what terrible blunders had been made in tramway work by persons who knew something of motors and very little of tramways. The inventors of these machines had, after learning electrical engineering, studied the details of the art of coal-cutting, and adapted their motors to it. The only criticisms that had been made, from a mechanical point of view, had been upon the Ingersoll drill. Not a single word had been said as to the electrical driving. It had been stated in the discussion that the wheel-cutting machine was better than the bar-cutter; but the amount bared with the bar-cutter was, if anything, rather more than with the wheel. He believed that the first machine, which used to tear both itself and the coal-face to pieces, and to throw itself off the rails, and hang on by the cutter-bar, travelled at the rate of about a yard a minute. The authors had stated that they were going to try a reciprocating machine. That was one of the most difficult problems that an electrical engineer could have to deal with. To produce anything on the reciprocating principle larger than the electric bell, and make it work with fair economy, seemed exceedingly difficult.

* Abstract of discussion on the Paper read before the Institution of Civil Engineers.

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Mr. H. W. RAVENSHAW observed that series-wound motors were always used for high voltage because they required comparatively few turns on the magnets, whereas shunt windings for high voltage required a large number of turns, and there was a great liability to failure of the insulation if the shunt-circuit was broken. The only difficulty with a series-wound motor was, that when working on a constant-potential circuit, if the load was taken off the machine was liable to run away at a very high speed. He had been working on the subject for some time, and had found that by using iron or steel having a great amount of hysteresis, *i.e.*, retaining the magnetism induced in it, he could make a motor which would not race. Employing Dr. Hopkinson's curve for hard mild steel, he came to the conclusion that, in the case of a machine he was building, which was intended to run at 600 revolutions, if he used soft iron magnets it would make on open circuit about 2,400 revolutions per minute, which would mean the destruction of something in connection with it. With mild-steel magnets, the maximum speed would be only 1,800 revolutions, a reduction of 25 per cent. But, by employing an automatic switch so arranged that when working at full load the two halves of the magnets would be connected in parallel circuit, and when below half load they would be connected in series, he found that with steel magnets the maximum difference would be from 600 revolutions at full load to 780 revolutions with light load. That would be an allowable variation in any case where great regularity was not required, and between full-load and quarter-load the speed would not exceed 680 revolutions per minute.

Mr. C. W. ATKINSON, in reply, explained the method of working the cutter-bar. Disk-cutters might be employed where the roof was very strong, and where there was little danger from jamming; but in most cases there was this risk, and consequently the bar-cutter was more generally useful. Several speakers had stated that the wear and tear of the compressed-air machines was much less than that of electric motor. He did not think that was the case. The whole machine shown in the diagrams was completely enclosed in dirt-tight cases, the gearing itself running in oil, the only revolving part visible being the cutter-bar, and that formed a dirt-tight joint at the gear-box cover, so that after many months' running, when the lid was taken off, the oil was perfectly clean. The consequence was that whereas in air-machinery they considered it a fairly good record if a pair of brasses wore two or three months, the wear of the brasses in the electric-machines was so small that after some months it was hardly perceptible. He thought, therefore, that the mechanical wear was less in the electrical than in the compressed-air coal-cutting machine. In reference to electrical wear they had never found any difficulty. The armatures were very strongly constructed, the repair required was only on the commutator, and in their experience that had been extremely small. Several machines had been running for years without requiring anything more than an occasional turning up of the commutator.

Mr. LL. B. ATKINSON said that exception had been taken to the authors having used the results of figures published originally in 1874; but it would appear from the remarks of Professor Lupton, that the only improvement he was able to record since that date was one of 25 per cent., and he appeared to have fallen into the error of believing that he could add this to the 31 per cent. efficiency, making it up to 56 per cent. It was, however, only 25 per cent. of 31, or about 6 per cent. more. Prof. Robinson had referred to the experiments at Birmingham, but he did not say whether he took the brake horse-power of the generating engine and of the motor, or whether he took the indicated horse-power. The authors had been careful to state that they took the brake horse-power of the engine and of the motor. It had been stated that the Paris figures might be very much improved. Possibly they might; all that the authors had ventured to do was to deal with the figures which had been actually obtained, in working with the electricity and with compressed air. They had given the figures obtained from working tests of the motors; the only remaining element being the loss in the cable, and that, in the present stage of electrical science, was a mere matter of arithmetic, and not a question involving any theory. Another important point upon which special stress had been laid was the question of the safety of electricity in fiery coal mines. Prof. Lupton and Prof. Forbes had contested the authors' statement, that the arrangement of covers designed by them afforded a safe means of employing electricity in mines. The authors had stated that all experiments went to show that there was very little danger of ignition, but that if there was any, the proposed arrangements obviated it. Prof. Forbes said that the casings looked very nice in the drawings, but as a matter of fact would not exclude the gases. Mr. Brain thought if they could prove their case and keep the gas out for two hours mining engineers would be satisfied. In order to settle that point they had one of the boxed-up motors placed inside a large box filled with coal-gas, or coal-gas and air. After five hours they drew out, by means of a pipe, some of the gas inside the cover surrounding the armature. This was passed through the eudiometer, and they endeavoured to explode it with an electrical spark, but were unable to do so either when it was mixed with equal volumes of air, or with four volumes of air, or taken as it was from the interior. As a check they ascertained by experiment that they could explode a mixture as weak as 1 in 14. For the purpose of measuring the actual proportion of gas inside the covers, Mr. Pitkin had kindly lent them one of his gas detectors, which were very sensitive. The result showed that after five hours, in an atmosphere with very much more gas than would be found in any coal mine in existence, only 0·5 per cent. of gas could be detected in the chamber. He thought that that answered both Prof. Forbes' theoretical objection and also the remark of Mr. Brain. He might mention that the motor was stationary, but that was rather a disadvantage, as it was found that the chief leakage was through the bearings. When the motor was running the oil was evenly distributed on the bearings, and there was no tendency to leakage. Prof. Forbes has dwelt at great length on the danger of using motors, and afterwards called their attention to the Tesla motor. They had heard of that machine for two or three years, and it had always been going to take them by storm, and do many wonderful things. The last time he made inquiries about it, nearly a year ago, he found that it was still unpurchasable even from the manufacturers in America. He thought, therefore, that they ought not to wait until the motors had been perfected before attempting to do mining by electricity. Prof. Forbes had admitted that there was a difficulty about starting the Tesla motor, and if so that would be a fatal objection to the employment of it for coal-cutting. Sometimes, after a stoppage or a fall of the roof, the cutter-bar became jammed so tightly that a man might pull as hard as he could on a long lever placed between the bolts of the coupling and not be able to move it. By suddenly switching on a current to a motor that would take 25 amperes, with an engine with a heavy fly-wheel, they might get 100 or 150 amperes for a second or two, and that would pull the motor clear almost of any stoppage. The Tesla motor was difficult to get to start at all, and could not possibly move the machine in a case of that kind. The great advantage of electricity in coal-cutting was the enormous power of starting where there was a block. It was surprising to see how a machine weighing 1½ tons would lift itself up off the rails at starting if the cutter was jammed. With reference to the question of the relative merits of the bar-cutter and the disc-cutter, two or three speakers had stated that they believed the latter would do the most work, but unfortunately they had given no data and no reason for the supposition. He knew that the makers of disc-cutters were very particular to choose soft materials to work in, and would not try them in hard. The authors, on the other hand, had considered that they ought to cut in what the manager of the pit thought was stuff that he could best afford to waste, and the cutters they had designed were used in material which disc-cutters would probably not work in at all. He believed that Mr. Frederick Hurd, who had had a great deal more experience than any one present of disc-cutters, looked favourably on the form of cutter given in the Paper, after having considered the relative merits of both. Prof. Lupton's argument that they ought not to attempt to use electricity in coal mines because there was a remote possibility of an explosion, might be applied to almost every class of machinery. There were boiler explosions and railway collisions, and cables were occasionally overwound with serious results; still they did not say that those mechanical contrivances ought not to be used because accidents might possibly happen. The proper way of approaching the subject was to inquire if the thing was worth doing. Prof. Lupton said that it was, if the tables of efficiencies given in the Paper were correct, and he did not seriously confute them; Mr. Atkinson therefore concluded that it was worth attempting, and the Paper was the record of what they had done in that direction. Reference had been made to the firing of gas by sparks from a pickaxe or from any steel instruments striking against a hard material. Mr. Atkinson had recently read a report of the Prussian Fire-damp Commission, in which he found that the Prussian Commission decided to investigate this question, but afterwards renounced it on account of the experiments of Messrs. Willner and Lehmann at Aix-la-Chapelle, on the inflammability of mixtures of fire-damp by incandescent metallic wires and electric sparks, which proved that even violent sparks from rupture of the current, accompanied with the explosion of fragments of iron in a state of combustion, had no effect on the inflammation of fire-damp. The results, therefore, of experiments so far had been to prove that the danger had been very much over-rated, whilst the system adopted by the authors practically excluded the gas from the point of danger. Mr. Snell had supported the view which the authors put forward, that under normal conditions a motor would be unlikely to ignite gas; but admitted also the advantage of arranging it, so that even under abnormal conditions no danger would arise. Mr. Snell had also upheld the opinion of the authors, that the whole armature ought to be protected, and not the commutator only. In the course of his remarks, Prof. Lupton had severely criticised the use of electricity in mines where gas was present, on the ground that, unless certain precautions were taken, danger was to be anticipated, and, therefore, advised the use of compressed air, unless it could be shown that electricity offered great advantages; but Prof. Lupton would lead his hearers to suppose that this advantage did not exist, and that, as the figures given by the authors in some cases related to machinery made and tested a good many years ago, they were no longer to be relied upon, owing to the great improvements which had been made since. Prof. Lupton had suggested further, that there should be a competition between electrical and compressed-air plants transmitting 10 H.P. to a distance of 10,000 yards. Table V., which the authors had calculated, showed what results might be anticipated of such a trial, taking Prof. Kennedy's experiments in Paris, and well authenticated trials of dynamos and motors as the basis of the calculations. He omitted to give any tables or details of trials to prove his contention, and in the absence of these data, and in the face of the fact that all existing records supported the authors' figures,

Table V.—Compressed Air *v.* Electricity.

Transmission = 10,000 *yards.*

—	Size of pipes.	Engine B.H.P.	H.P. given by generator.	H.P. lost in main	H.P. put into motor.	Motor B.H.P.	B.H.P. motor. B.H.P. engine.	Cost complete & erected
	Inches							£
Air	3	62·1	38	19	19	10	0·16	2,500
	4	39	23·6	4·6	19	10	0·26	3,100
	5 & 4	35·8	21·8	2·8	19	10	0·28	3,445
Electricity	$\frac{19}{17}$	19·2	16	4·6	11·4	10	0·52	1,580

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Prof. Lupton's suggestion ought not to be entertained. In criticising Table II., Prof. Lupton referred to an installation running at the Trafalgar Collieries, in which the distance was the same, and although a cable of nineteen wires was used instead of seven, as described in Table II., there was a loss of 20 per cent., whereas in the Table, a loss of 10 per cent. only was shown. Prof. Lupton pointed out that the voltage used at the Trafalgar Collieries was one-half of that proposed to be used by the authors, and this statement accounted for the whole difference, for by doubling the volts, and keeping the size of the conductor unaltered, the loss would be reduced to one quarter, so that the cable might be halved in size, and the loss still be one-half of that with the lower volts. This corresponded with the Table in every respect. Prof. Lupton stated that a 3in. pipe would be ample for a 10 H.P. engine working with compressed air: but every maker of compressed-air machinery to whom the authors had mentioned the point, had selected a 4in. pipe for the work, when working at an ordinary pressure of about 50lb. to the square inch. Prof. Lupton's alterations, therefore, to the figures and prices were incorrect. He also asked what was the price of the machine, compared with that of a compressed-air engine; these costs were given in Table II., the price of both electric and compressed-air machinery being taken as an average market price. Professor Lupton's remarks as to the apparently contradictory advice given by persons whom he had consulted as to the proper voltage to use in transmitting power were capable of an easy explanation. Small motors of ½ H.P. to 1 H.P. were difficult to wind for more than 150 volts; if, therefore, it was desired to run them from mains supplying large motors, at, say, 300 to 500 volts, it was better to work either two or three of them in series, or to insert resistance, and although by this means the efficiency might be reduced by 50 per cent., yet the useful work obtained was greater than would be got from a compressed-air motor of the same size, and to which power was being transmitted for an equal distance. The question as to the best voltage to use was one which an engineer in laying out a plant would carefully consider, in order to get the best results; but criticisms concerning the efficiency of motors as small as ½ H.P. running off transmission systems, involving, perhaps, 200 or 300 H.P., were not very vital to the question. The authors regretted that considerable bias in favour of a particular system, and apparently want of practical experience of any other, had led Professor Forbes to condemn the arrangements described by them in unmeasured terms. He appeared to be under the impression that most coal mines were normally filled with an explosive mixture, and that the working face was the most dangerous place in the mine; whilst, as a matter of fact, it was generally a part where the air was purer and more free from gas, owing to the thorough ventilation, than in almost any other. It was perfectly true that, if the authors' motors were left for, say, a week, in an explosive mixture, it would be possible to imagine an explosion occurring from their use; at the same time, such a condition was not in any way likely to occur, and the supposition of the authors, that an electric motor would not be worked continuously in such a mixture for a longer period than two or three hours, was one that allowed an ample margin for every practical case. In reply to the suggestion of Prof. Forbes that the words used in the Paper were intended to produce the impression that this machinery had been employed in fiery mines, although such had not been the case, the authors might point to a pumping plant, working with one of these enclosed motors, which had been in use in the Murton Colliery of the South Hetton Coal Company for seven or eight months, and which had been approved both by the mining inspectors and by the engineers of the colliery, and which had led to no fires or explosions. Prof. Forbes had pointed out the danger of using electric cables at all; but the experience of all colliery owners and managers who had tried them had shown that, if they were properly put down in the first instance, and had reasonable supervision, difficulties of the kind suggested did not occur in practice. With regard to the Tesla motor—although machines of this class undoubtedly had a future before them, the authors thought that no engineer practically acquainted with the requirements of coal-cutting machinery would recommend a motor where, with the latest improvements, the torque exerted at a standstill is considerably less than when running; and although in that motor no commutator is used, nevertheless it would be equally desirable to enclose the armatures, to prevent sparking in the event of a wire being broken. The remarks of Prof. H. Robinson called for attention, he being the only speaker who endeavoured to support the contention that compressed air was as efficient, or more efficient, than electricity, by any show of figures. But the authors could only assume that the results given as *efficiency* represented the ratio between the indicated horse-power of the engine and the indicated horse-power of the motor, in which case, as bearing on the present discussion, they were not comparable with those in the Paper. But if the results given by Prof. Robinson could be maintained by publication of figures or records, this should certainly be done, as they were considerably in advance of what the authors had seen. In reply to Mr. Pearsall's criticisms, the figures in Table II. were estimated or calculated, and were placed side by side for the purpose of comparison. The data on which these figures were calculated were as follows:—In the electric transmission the loss in the cables was accurately known, while the efficiency of the electric motor had been determined by careful experiments to be 85 per cent. The brake horse-power of the steam-engine was also arrived at by a knowledge of the efficiency of the dynamo, gained by careful experiments. In the case of compressed air, the efficiencies of the compressing plant and of the air motor were taken from the figures in Prof. Kennedy's Paper before the British Association on the "Popp" system in Paris, the prices in each case being those given by leading makers. Mr. Pearsall gave a considerable number of figures, and ended by saying that compressed air, with an efficiency of 85 per cent., was an accomplished fact, which could be seen any day; the authors only regretted that he did not indicate where it could be seen, as they were quite sure that a large number of engineers would be interested in a result which was certainly unique.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *October* 10, 1891.

The New York Electric Light Subways.—The subway wail has broken out again, and with full force; this time it is in the form of a desperate protest on the part of the East River Electric Light Company against the extortion of the Subway Company. Not only does the latter organisation demand $1,000 yearly rent per duct, but charges extortionate prices—from $3 to $6 per cubic yard—for excavating, and is alleged to furnish the necessary pipes to the Electric Light Company at 60 or 70 per cent. above cost. The state of things is, in fact, so bad that the electric light companies cannot run their wires in thinly populated districts, for they have only a few customers per duct and still have to pay $1,000 rental. The whole history of the Subway Company has been one of crooked business methods and bad service; but there appears to be no way of escape.

Regulator Socket for Incandescent Lamps.—One of the interesting small novelties recently brought out is a regulating socket for incandescent lamps manufactured by the Reis Electric Specialty Company; it is intended for use only on alternating circuits, and consists of a small coil of variable impedance enclosed in a somewhat enlarged lamp socket. More or less of the windings on this coil are utilised according to the different positions in which the ordinary key of the socket is turned, thus varying the light of the lamp. It is possible by this apparatus to turn the lamp down to a dull red or allow it to glow at its full brilliancy. There is, of course, a slight amount of energy loss in hysteresis and heating, but not considerable, and where the electrical supply is furnished by meter the use of this socket will produce a saving.

Edison and Electrical Traction.—Mr. Edison is again promising wonderful things in the electric street railway line. His apparatus appears to be some arrangement by which electric current at low potential is to be supplied through the ordinary rails. This is a subject that Edison has been pursuing off and on for several years, the intention being to use a voltage so low that the leakage from the rails, even when the ground is wet, will not rise to a prohibitive amount. It will be interesting to learn how he proposes to effect his distribution, possibly by means of supplying individual sections of the line from continuous current transformers. From what he says an important factor of the invention consists in a device enabling him to take up current from the rails even in muddy weather. He also says that he is building a large electrical locomotive to be used in connection with some of Mr. Villard's plans, and expresses himself in favour of taking current from stations about 20 miles apart, and perhaps replacing steam, not all at once but gradually.

The New York Rapid Transit Committee.—The plan apparently favoured by the New York Rapid Transit Committee is the one almost forced upon them by Mr. Worthen, their consulting engineer. It is a modification of the old arcade scheme of a four-track road under the surface of Broadway, and it involves the construction of a tunnel 44 feet in width, wide enough to accommodate the cars, and supporting the entire mass of superincumbent earth. The top of the tunnel is intended to be nine feet below the surface, leaving room for the somewhat complicated system of pipes that occupies our streets above it. It goes without saying that such a plan will be enormously costly, and it is very doubtful indeed whether private capital could be secured for it. It would be a very difficult matter to earn reasonable dividends on a sum of more than $50,000,000, particularly in the face of the active opposition that would be offered by the present elevated roads. The plan could probably be carried out successfully by the city at a sufficient expenditure, but whether a company could be organised to do the work is doubtful.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company announce the payment by warrants, on November 2nd next, of interest for the half-year ending October 31st, on their Four per Cent. Mortgage Debenture Stock. The transfer books will be closed from October 28th to November 2nd, both days inclusive.

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CORRESPONDENCE.

WHY BELITTLE PIONEERS?

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your leader on multiphase currents puzzles me. Can it be that *The Electrician*, that sound and reliable journal, has for once discarded its guiding principle and given us irresponsible opinions instead of solid scientific facts? Or can it be that you have mistaken one for the other? In this leader you say, "Meanwhile it is our duty to watch the new developments, to understand them if we can, and to keep our readers posted as to what is being done with them." A most excellent sentiment; but do you carry it into practice? A person who knows nothing of multiphase currents, and takes up *The Electrician* hoping to get some instruction from your leader on this subject, will naturally come to the conclusion which you so tersely express at the end, namely, that "the whirling of the armature at Frankfort is in more senses than one a *tour de force*." In plain English this means—"Yes, it is true the motor runs; but after all this is merely an experiment made at great cost and under conditions which do not occur in practice, and therefore the whole thing has no practical importance." It is a curious commentary on your concluding sentence that an hour after reading your article I received a letter from one of the Directors of the Oerlikon Works, in which the writer tells me that they had just started their three-phaser, and were now driving their works by three-phase current. Is this also a *tour de force*?

At the last British Association meeting a learned professor went to the trouble of reading a paper in which it was stated that there was really nothing in this Lauffen experiment, that an ordinary alternating current would answer equally well, and that, in fact, ever so much better work had already been done in America. This opinion was given before the Lauffen transmission plant had been started; and although now the engineers of this undertaking can afford to smile at the prediction of failure, at the time it must have caused them some anxiety; for remember, that practical engineers, even if they go their own way, do look up to professors. Why, then, should the professor dishearten them at a time when they most want support and when moreover it is too late for them to follow any advice, good or bad? To judge from the attitude of some English scientists and newspapers one would be led to think that Tesla, Bradley, Dobrowolsky, Brown, and the rest of the multiphase contingent, were a band of electrical miscreants, having some dark design against the industry, instead of pioneers striving to open up new fields for it. But it has always been so. How did the old-fashioned electrical engineers (that is, the majority of us) sneer at Gaulard and Gibbs even after the taint of perpetual motion which disfigured their patent had been duly discounted, and Dr. Hopkinson had shown that a high efficiency of transformation could be obtained? Or, to come nearer our own time, was not Ferranti attacked from many quarters for his 10,000-volt scheme; and was he not told over and over again that it would be a failure? What strikes me as so incongruous about all this is that men who in the ordinary way of business would refuse to give scientific advice, except for the consideration of a substantial fee (and quite right, for consulting engineers cannot, any more than other men, afford to work gratuitously), are so often ready to give discouraging advice to the pioneers, and that even without having been asked for advice or offered a fee. As long as private persons show their philanthropy in this manner no one has a right to interfere. In this free country everybody is at liberty to belittle everybody else as much as he pleases; but when scientific journals begin to give this gratuitous advice of a negative character, then their readers have a right to complain. I am quite aware that in taking up this position I lay myself open to the retort that you are convinced that the multiphase current is of little practical use, and that therefore you take it to be your duty to warn your readers against over-estimating its advantages. If this is the case, that is, if you really have got to the bottom of this intricate subject, then I pray you let us have a series of very exhaustive articles on it in *The Electrician*; and I promise you that not only outsiders like myself, but even the Haselwanders, Teslas, and Dolivos will read these articles with the greatest interest and benefit.

But perhaps I have misunderstood you altogether. Your leader was really based on an article in *Industries*; and my quarrel is, therefore, rather with that paper than with *The Electrician*. Then you might ask, "Why not send this letter to *Industries*?" Well, the reason is that *Industries* did not publish a leader on this subject, and you did. Now it is one thing to publish an article plentifully diluted with "if's," and "when's," and "let us suppose," and "say," and "assume," this, that, and the other, to get a basis for a theory; and it is quite another thing to publish a leader in which these qualifying things have been omitted, and the unfavourable conclusion of the article is put forth with all the weight of an editorial pronunciamento.

I will not here enter into the question whether the Lauffen installation could have been equally well carried out with ordinary synchronising machines and a single-phase alternating current. The learned professor and the learned gentleman who wrote the articles in *Industries* evidently think that it could; but against these opinions there is the broad fact that it has not been so carried out, and that, in fact, nothing even approaching such a transmission plant has ever been made with any kind of current. From your remarks it would seem as if you regarded the use of the simple alternating current for transmission of power as a kind of revelation brought to light by Mr. Mordey's experiments. I do not know to what experiments you refer, but it may interest your readers to learn that electric transmission of power by ordinary alternating currents is no longer an experiment, but has become an established fact. I personally know at least of one such power transmission, in which four of my ordinary 100 H.P. alternators are used. This has been at work for the lighting of Cassel since the spring of this year. The plant was supplied by the Oerlikon Works; and it is therefore obvious that this firm when deciding on the Lauffen work knew perfectly well what could be done with the simple alternating current. Yet they elected to use the three-phase current. Is that not a better proof of its suitability to this particular kind of power transmission than the opinion of the writer in *Industries*? Of course, the great merit of the system is the starting power. You hint rather than assert that this is not particularly great. Mr. Ravenshaw, your correspondent, has observed that some time elapses between the moment when the motor is started and the water appears on the top of the artificial fall. Considering that the main must be nearly 100 ft. long, and that centrifugal pumps require a certain minimum speed depending on $\sqrt{2gh}$ before they give any water at all, the lag of the water behind the motion is not very surprising; yet it would be a fallacy to suppose that there is no load on the motor when starting. There is friction and inertia to be overcome, the latter being that due not only to the weight of the revolving part of the motor, but also the disc of the pump and the water in it. The question of maximum torque at starting is so important that at the last meeting of the Testing Commission which I was able to attend, it has been decided to make special tests in this direction. When these and all the other tests will be published we shall be in a position to correctly judge the merits or otherwise of multiphase currents; but meanwhile do not let us belittle its pioneers. The German and American electricians have always been ready to give their English colleagues and rivals credit for their work: why should we be less just and courteous on our side?—Yours, &c.,

GISBERT KAPP.

Wimbledon, October 17, 1891.

MULTIPHASE CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your article on "multiphase currents" I find that you are overlooking some of Tesla's patents. This inventor describes quite clearly in his patents from '87 to '88 the three-phase current as applied at Frankfort; and the only novelties

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which this Exhibition brings to light are important constructive improvements in its application.

The general reports upon the Lauffen-Frankfort transmission give the impression that to the application of the three-phase current is due the favourable issue of the experiment. I wish, however, to call your attention to the fact that the principal object of the experiment was to prove the possibility of transmitting high-tension currents over long distances by naked wires, and with such a degree of security against danger and such a small amount of leakage as to demonstrate that this mode has the right to exist commercially. The adoption of the three-phase current only increased the difficulties to be met, since the generator, the transformers, switches and controlling appliances, as also the conductors—a most important disadvantage—became more complicated than they would otherwise have been had the usual alternating current been chosen.

The only reason justifying the choice of the three-phase current was to demonstrate its advantages when applied to several small motors at the same time.

As the line at Frankfort has not been tried up to the present with more than 20,000 volts, I think it a little over-hasty to say that the insulators are unable to stand the pressure of 30,000 volts. I only wish to point out that considering the employment of ordinary insulators on two-thirds of the line, the result must be looked at as an exceedingly satisfactory one. I quite agree that as soon as a practical single-phase motor is produced we shall not hear much about multiphase currents, except in some special cases, as for distribution of power in a big workshop where we need no transformation, and perhaps, also, for mining purposes.—I am, &c.,

C. E. L. Brown.

TEMPERATURE CO-EFFICIENTS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: It is with great pleasure I have read Mr. Weaver's letter in to-day's *Electrician*. It is some years since I have tested Willoughby Smith's core; but as all the gutta-percha core made by the best known manufacturers has practically the same temperature co-efficient, my remarks will equally apply to Mr. Weaver's tests. The tables of co-efficients found in all text books are merely approximations, and must be taken as such. Instead of $(1 + \alpha)^t$, the true formula is probably something like this—$(1+\alpha)^t - m^t$, where α = co-efficient for 1°, m is a constant, and t = the difference between standard and observed temperatures.

Last year I took a series of tests on six coils of gutta-percha core at various temperatures with a view of ascertaining their correct co-efficient; which tests proved conclusively that the co-efficients did not vary simply as the log of the difference of temperature, but increased more rapidly as the temperature decreased. My values I found, however, could not be taken as being absolutely correct, owing to the fact of the core being of recent manufacture, and therefore its insulation was not stable; and I venture to suggest that this probably accounts for the majority of Mr. Weaver's tests at the same temperature being higher in Table No. 2 than in Table No. 1.

It would considerably facilitate the corrections for temperature being made if companies would only stipulate in their specifications to contractors that all insulation tests of the cable should be reduced to a temperature of 60°F., the core having been previously tested at that temperature, instead of still adhering to the 75°F. temperature. I am aware manufacturers of electric light lead have already adopted 60°F. as their standard temperature; this has, however, probably been done entirely from a business point of view. Practically under no circumstances will the temperature of a submarine cable have a greater variation than between the limits of 34°F. and 86°F.; so by making the standard 60°F. the greatest correction it would be necessary to apply would be for difference of temperature of 25°F., and whatever error existed in our co-efficient would only be multiplied by that number instead of, as at present, by either 41° or 11°; and as by far the greater number of tests are taken nearer a temperature of 60° than of 75°, there would be a decided advantage.

I have found cables vary considerably when corrected for large differences of temperature, some of them correcting fairly well with the ordinary log formula; where, however, there is a great difference between the result obtained by correction for a low temperature and that obtained when the core was tested at the standard temperature it points to a slight weakness in the core itself. This is practically either due to bad joints or the conductor in places not being quite central.

These weaknesses being unaffected by temperature are more apparent at low temperatures where the resultant fault is small. This, again, is another reason for making the standard lower, as it thus gives the contractor a better opportunity of localising any small fault in the core before sheathing.

Apologising for trespassing so much on your valuable space, —I am, &c.,

J. Leslie Fuller.

Westcombe-park, October 17th.

[Errata.—An over-zealous printer expanded the abbreviation K^t. into kilowatts in Mr. Weaver's letter in our last issue. The tables, of course, refer to megohms per knot.]

THE INTERNATIONAL OKONITE COMPANY.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I notice in your report of the meeting of our Company a statement which is incorrect. In explaining some causes which have led to less demand for our goods, I stated that the shipping orders we had received the year before from Messrs. Mather and Platt had fallen off 50 per cent. in the current year. Your report implies that the orders of Mather and Platt had fallen off 50 per cent. As I know this to be the reverse of the truth, I could not have made such a statement, and beg you, therefore, to allow me to correct the report upon this point which appeared in your journal of October 16th.—I am, &c.,

John Shaw, Commercial Manager
International Okonite Company, Ltd.
100, Queen Victoria Street, London, E.C.,
October 21, 1891.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

Tenders Invited.—The Minister of Public Works of Egypt announces in our advertisement columns that he is desirous of receiving tenders for the installation of the electric light at the Abdin Palace, Cairo. The work to be done includes the supply and fixing of the generating plant and all the necessary apparatus, except the brackets, pendants, &c.; and the installation is to include about 3,000 incandescent lamps and 25 arc lamps. Conditions, plans and schedules may be obtained at the offices of the Administrative Service of the Minister of Public Works; and tenders are to be delivered before noon on December 1, 1891.

———Tenders are invited by the Municipal Chamber of Braga, Portugal, for the public and private lighting of the city, either by means of gas or electricity. Official forms of tender may be obtained from the Municipal Offices. The basis of tendering will be about £3. 15s. per lamp.

Tenders Accepted.—The Town Council of Bradford have decided to accept the tender of Messrs. Andrews and Preece (Limited) for the providing and fixing of fittings required in the lighting by electricity of rooms in the municipal buildings, for the sum of £898, exclusive of fittings to be provided by the Corporation, at an estimated cost of £450.

——— The tender of the Brush Electrical Engineering Company has been accepted for lighting the Bilston Market Hall.

Christiania.—The tenders sent in for the Christiania Central Station were opened on October 12th, and the result will be made known in about a month. The tenders for equipping the entire station were from Messrs. Crompton and Co. (Limited), Messrs. Siemens Brothers and Co. (Limited), the Electric Construction Corporation (Limited), Messrs. Sharp and Kent, Messrs. Woodhouse and Rawson United (Limited), Messrs. Siemens and Halske, the Edison General Electric Company, New York, Messrs. Schuckert and Co., the Thomson-Houston International Electric Company, Hamburg, the Helios Company, Compagnie Centrale Edison, Messrs. O. L. Kummer and Co., and the Actiengesellschaft für Chromakkumulatoren,

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Berlin. For supplying the boilers, tenders were received from the Düsseldorf-Ratinger Röhrenkessel Fabrik, Ratingen ; the Babcock-Wilcox Company (Limited), the Gohrig und Leuchs Kesselfabrik, Darmstadt ; and the Steinmüller Röhren-Dampfkessel Fabrik, Gummersbach. Callender's Bitumen, Telegraph and Waterproof Company (Limited), were the only tenderers for supplying the cables ; Messrs. T. and A. Jenssen and Dahl, of Christiania, alone tendered for supplying the steam engines ; and Messrs. Mather and Platt were the only tenderers for supplying the dynamos and instruments.

Sales by Auction.—Messrs. Wheatley Kirk, Price, and Goulty, in conjunction with Messrs. Edwards, Son, and Bigwood, of Birmingham, are instructed by Arthur Henry Gibson, Esq., the receiver and manager of Taunton, Delmard, Lane, and Co. (Limited), in liquidation, Star Tube Works, Heneage-street, Birmingham, to sell by public auction, at an early date, on the premises, the entire contents of the above well-known works. The catalogue will include beam, vertical, and horizontal steam engines, single and coupled ; "Root's" patent high-pressure tubular boilers, with from 100 to 388 tubes ; Cornish, vertical, and egg-ended boilers ; and a quantity of tube rolling and drawing machinery, loose plant and effects, &c. Further particulars will be found in our advertisement columns, and catalogues may shortly be obtained of the auctioneers.

Messrs. W. T. Glover and Co.— This firm report a very busy summer, necessitating the laying down of additional plant to meet the increasing demand for their manufactures. They have recently registered a new telegraphic address—"Glovers Salford." Mr. Henry Edmunds, who has been attending the Electrical Congress at Frankfort, has now returned to the Company's London offices, 39, Victoria-street, Westminster, S.W.

Messrs. Ernest Scott and Mountain (Limited).—The new works recently erected by Messrs. Arthur and Co. at William-street, Anderston, are lighted throughout by electricity, the installation having been carried out by the above firm, under the superintendence and to the specification of Mr. W. A. Bryson, consulting electrical engineer, Glasgow. The plant consists of two Tyne compound-wound dynamos, each machine being capable of giving an output of 25,200 watts when running at a speed of 670 revolutions per minute. The current from the dynamos is taken to a very massive switchboard, consisting of two large enamelled slate bases, placed one above the other. On the lower slate base two coupling switches are placed, arranged so that the dynamos can be coupled parallel or run singly if required. On the upper enamelled slate base five double-pole main switches are fixed together with automatic cut-outs. These switches control the five floors of the building by separate circuits, so that any floor can be switched off from the dynamo room. There are altogether 600 16 c.p. incandescent lamps, suspended from the ceiling by flexible pendants, each pendant being fitted with a china ceiling rose containing a fusible cut-out. We understand that Messrs. Ernest Scott and Mountain (Limited) are extremely busy at the present time in their electrical department.

Messrs. Drake and Gorham.—Shendish, the residence of Mr. A. Longman, has recently been fitted with the electric light by Messrs. Drake and Gorham, the power being obtained from a gas engine which also does the pumping for the house. The installation consists of an accumulator capable of discharging up to 50 amperes and about 100 lights.

Brush Electrical Engineering Company (Limited). — The secretarial and managerial offices of this Company have been removed to Albert-buildings, 49, Queen Victoria-street, E.C.; the offices of the chief engineer will remain at 112, Belvedere-road, S.E.

Dissolution of Partnership.—Mr. John Ferguson and Mr. John M'Kay have retired from the firm of M'Whirter, Ferguson, and Co., electrical engineers, Faraday Electric Light Works, Campbell-street, Govan, Glasgow ; and the business will in future be carried on under the same name by Mr. William M'Whirter, who will pay all debts incurred by the old firm.

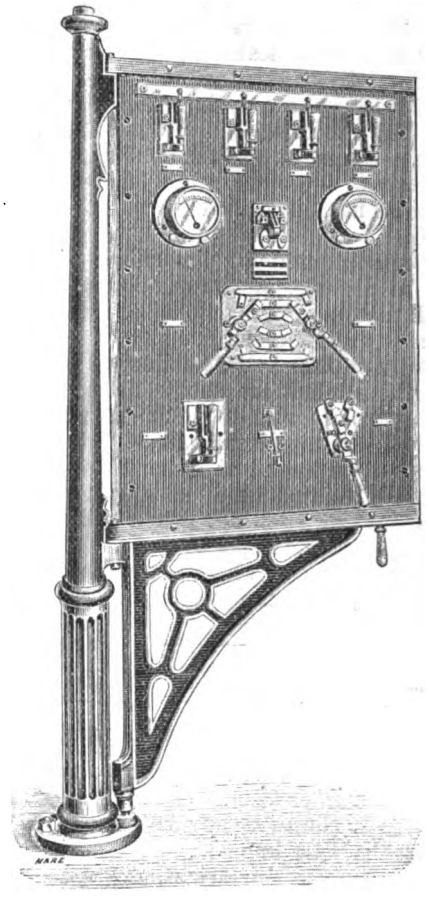
Cadogan Electric Light Company (Limited).—A petition for the compulsory winding up of this Company has been presented by Mr. Henry Lowenfeld, of 31, Lowndes-square, and is down for hearing before Mr. Justice Kekewich on October 31st.

Bankrupts.—At a meeting of the creditors of Hugh A. Fergusson, Berkeley Lodge, Upper Berkeley-street, held on Thursday at the London Bankruptcy Court, before Mr. H. Brougham (Official Receiver), it was resolved to wind up the estate in bankruptcy, and appoint Mr. C. J. Singleton, Staple Inn, trustee, to act with the assistance of a committee of inspection.

——— A receiving order has been made against Victor Silberberg, who is described as of 47, Oxford-street, electrical fittings manufacturer, trading as the Electrical Fittings Manufacturing Company. The act of bankruptcy is a deed of assignment to creditors. No particulars transpired at the meeting.

Lamps and Lamp Shades.—The *Observer* of Sunday last contains an interesting article on the above subject. The remarks of the *Observer* correspondent apply chiefly to gas lamps and shades, but many of the fancy designs referred to are of equal service in electric lighting displays.

A Swinging Switchboard.—Messrs. Newton and Hawkins, of Taunton, make a switchboard arranged with hinges, these hinges being attached to hangers on the wall, or to a cast-iron pedestal



bolted to the floor. This allows connections to be got at, and alterations to be made with great facility, enough slack being left in the wires to allow the whole board to be opened like the door of a cupboard.

COMPANIES' MEETINGS & REPORTS.

Eastern Extension, Australasia, and China Telegraph Company (Limited).

The thirty-sixth ordinary general meeting of this Company was held on Wednesday last ; Sir John Pender, K.C.M.G., presiding.

The SECRETARY (Mr. F. E. Hesse) read the notice convening the meeting and the minutes of the last meeting, which were approved by the present meeting and signed by the Chairman as correct. The report of the Directors was taken as read.

The CHAIRMAN : Before asking you to approve of the report I will, as has been my custom, first make some few remarks upon it. The gross receipts for the half-year under review amounted to £264,878, against £254,856 for the corresponding period of 1890, showing the substantial increase of £10,022, and this would have been even greater but for the fact that the accounts include two months' receipts at the reduced rates to Australia, to which I shall more particularly refer later on. The working expenses have been £71,476, against £76,670 for the corresponding half-year, showing a decrease of £5,194, which is accounted for by the ships' expenses having been lighter during the past six months than in the corresponding half-year of 1890. The net revenue has amounted to £155,165, against £136,675, for the corresponding period of 1890, showing an increase of £18,490, due to the causes already explained. Two interim dividends at the rate of 5 per cent. per annum have been distributed for the half-year under review, amounting to £62,500, and the balance of £92,665 is carried forward. The conversion of the Six per Cent. Debentures into Four per Cent. Debenture Stock has been satisfactorily completed during the past half-year, and it is gratifying to find that the new stock is quoted in the market at a substantial premium—6 to 8 premium. This stock was distributed among the shareholders at par. With regard to cable operations, further renewals have been made to the Tonquin-Hongkong section, about 140 knots of cable having been

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inserted since the last meeting, and the cable is now in good working order. Total length of cable, 469 miles. By degrees we shall practically renew this cable. Several small interruptions have occurred during the past half-year, but the traffic has been practically unaffected, owing to its transmission by the duplicate line. Since the close of the half-year the Madras-Penang (original) Cable has broken a short distance from where the renewal work carried out last year terminated; but the duplicate cable laid last year is carrying the whole of the traffic without the least delay, and no inconvenience has therefore been experienced. Fine weather is now reported to have set in in the Bay of Bengal, and as the s.s. "Recorder" will be in the vicinity of the break in a few days, it is anticipated that communication will be restored very shortly. The Company's station at Elephant Point at the mouth of the Rangoon River, which, as I mentioned at a previous meeting, was endangered by the rapid encroachment of the sea, has, by arrangement with the Indian Government, been closed, and a considerable portion of the cable between Elephant Point and Penang picked up and used elsewhere. An arrangement has also been entered into with the Dutch Government for extending the Company's system to Sumatra by laying a submarine cable from Penang to Deli, the centre of the tobacco district of Sumatra, from which an additional source of traffic is expected. The length of this cable is 166 knots. The cable will moreover open up an alternative route to Java and other portions of Netherlands India, and as it will be provided from the stock at Singapore, the work will be carried out at a comparatively small cost. It is with deep regret that I have to announce the death of our colleague, Sir Thomas Fairbairn. He was one of our Directors from the early days of the Company, and, though during the past few years he had suffered from bad health, still his mind was clear to the very last. We do not propose to fill up his seat at the Board at the present time, as the number remaining is sufficiently large to efficiently conduct the Company's affairs; but we shall always make it a point at our Board whenever an active member falls out to replace him by someone who will be useful to the Company. I have now given you some particulars of the work we have been doing during the last six months; and I will just supplement those remarks by saying that I am satisfied that you will be pleased with the accounts which we have put before you to-day. Very few companies indeed can carry forward the amount we have carried forward. It is only twelve months ago that I announced to you that we were negotiating for an alteration in our tariffs with the Australian Colonies. Six months ago I told you that we had completed those negotiations to our satisfaction; and to-day I am able to tell you, after some little experience, though a short experience, of the working at the reduced tariff, from 9s. 4d. to 4s., that I believe the Companies will not eventually lose in any way by the arrangement, and that the general telegraphing public will benefit very largely indeed. In saying this, however, I must also make this remark—that we have been dealing with English-speaking people—people who know the value of telegraphy—people who use it for commercial purposes; and as they find that the more they use it, the more trade grows, that is our hope in the future. We cannot calculate on the same results in countries where the English element is comparatively small to the population, such as India and China. We have made reductions there, but we have not got the same return. I make these remarks with the view of their coming before the English merchants in India and China, and I trust that they will think twice before they allow themselves to go back in the commercial race. I believe that submarine telegraphy has established such a connection between this country and commercial interests all over the world, that it is impossible to carry on business without using the cables. That is a bold statement; but I make it because I know something of commercial life, and I know where energy is applied and where strong will is exercised, they will find that the more closely they keep in touch with the mother country the more prosperous will their relations be. I cannot say so much of the local traffic; but in dealing with the Japanese and the Chinese we have got people who are very keen, painstaking, and persevering, and I think it likely that any good example set by the English community will be eventually followed by those who see that what benefits the English should benefit them also. The next time I meet you I hope to be able to tell you that the reduction in the tariff from 9s. 4d. to 4s. has been a practical success, and that it is likely to be a permanent institution. I cannot leave this subject about the reduction of tariffs without expressing my thanks, as I did last year, to the agents-general of our colonies who took part in the bringing about of this arrangement. Two of them are returning to their colonies. Sir Dillon Bell has already left, and Sir Graham Berry is shortly to leave. Sir Dillon Bell took an active part in the negotiations, and was very much disappointed to find that the state of things in his colony did not admit of their taking a share in the guarantee. But I believe his influence will be used in New Zealand to further the arrangement which I believe will be crowned with success, and that he will try and bring New Zealand into it, so that she may share in its advantages. Sir Graham Berry, who has throughout taken a most active part in this matter, is returning to Victoria, and I know that we shall have in him an intelligent supporter of any system that will bring into closer relations the Colony which he has so ably represented with the mother country. I know he believes that the more they can work together the more successfully will their respective interests be promoted. When just before coming here I looked through the speech that I made to you six months ago, I found that it was so full of details in regard to the questions of which I have been speaking to-day, that to go further into them now would only be repetition. Six months hence I hope I shall be able to congratulate you, the Directors, and the Colonies, upon the success of this grand experiment, which I feel sure is likely to prove satisfactory. When we see everything progressing well, and we can pay you good and steady dividends, adding to the reserve fund, and strengthening ourselves in every possible way, I think we ought not to forget the fact that a great Company like this has now attained a position when it should think of those who have been more or less identified in bringing about such great results—I refer to our staff generally. We are anxious that a fund should be established and promoted for the purpose of giving pensions to those who are in our service. This service is a peculiar one. It is one that requires intelligence, honesty, and a good deal of self-reliance. We have to send out young men to our different stations all over the world, and nothing pleases me so much as from time to time to find that when our stations have been visited by distinguished men from this country, we receive reports stating that our young men are a credit to the country and the Company they represent. Perfectly knowing the value of our staff, the important position they hold, and that they have to live like gentlemen, we want them when the time comes when they must retire to have something to look forward to on their taking that step; and I think that the Company in its days of prosperity can justly contribute to the fund required for enabling that to be carried out. It is proposed that the Company should contribute to a Pension Fund something like 5 per cent. per annum on the staff salaries, and the staff contribute 2½ per cent.; but the details of this proposal will be settled later on by competent actuaries. All that I ask you to-day is to approve generally what I have foreshadowed. Some years ago you agreed to contribute towards an Assurance Fund, and we are going now to practically merge that fund into the Pension Fund. The Company's 5 per cent. will amount to a little over £2,000 a year in addition to the £1,500 already authorised for the Assurance Fund, and we hope in a few years' time to accumulate such a fund as will enable us to make an allowance upon retirement that will place a man in more or less comfortable circumstances. I have now given you a general idea of what we want to do, and I feel confident that in the midst of our prosperity you will not forget that something is due to those who have helped to build up our success. I shall put no formal resolution to you to-day on the subject, as the details must first be thoroughly worked out, but six months hence I hope to be able to bring this matter before you in a more explicit and formal manner. I now beg to propose—

"That the report and accounts of the Directors, now submitted, be received and adopted."

The Most Hon. the MARQUIS of TWEEDDALE: I beg to second the resolution.

The CHAIRMAN: If any gentleman wishes to put any question to me regarding any point that I may have omitted, I will answer him with much pleasure to the best of my ability.

Mr. JOHN NEWTON: I do not think that a resolution of this kind should be passed without something being said from this side regarding the proposed pension fund. At a time like this, when we all see a profit on our investment in the Company, I feel convinced that there is not a shareholder who will not heartily endorse what you have said; and we are very glad to find that, although rather late in the day, you are proposing this arrangement in connection with our staff. I think it should have been proposed years ago. The shareholders are greatly indebted to the Directors for their successful management, and to the staff for the assistance which they have rendered. The staff have not the Directors about them; and you may depend, therefore, that we have splendid representatives when such reports are made about them as those to which the Chairman has referred. Another point which I think the shareholders have to congratulate you upon is the reduction of the tariff from 9s. 4d. to 4s., and I am very glad to see that that measure has been attended, so far, with success. I think that the Directors and the staff may be congratulated upon the successful result now shown, and I believe, as I have already said, that we shall all heartily support the proposed pension fund.

Captain LEWIS: If you will allow me, I should like to add my congratulations to the Directors for taking this subject into consideration I have served in many of the climates where our young men are, and I can speak well of their acts and doings. Every person who has travelled in China, Batavia, and the Eastern Archipelago, must know the diseases to which they are subject—dysentery and fevers of all kinds; and surely when a man has broken down in the service, he has some claim on a great and rich Company like this, just as in the case of the army, the navy and the civil service.

The CHAIRMAN: Before I ask you to pass the resolution, I wish to thank Mr. Newton and Captain Lewis for the remarks which they have made, as I believe, when they are printed and sent abroad, they will convey even more gratification to our young men than any remarks I might make. They are aware that I know all about them, and am interested in them; but when they find that the views held by the Chairman and Directors are approved by the shareholders it will be a double satisfaction to them. I am, therefore, quite sure that the remarks which you have made to-day will be just as much appreciated by them as they have been by ourselves. It has been the desire of this Board to make this Company strong in every sense of the word—strong in the support they have from their staff, strong in commanding the confidence of the shareholders, and, above all, strong in having the unanimous support and approval of the great body of people who use the telegraph system. With these remarks I beg to put the motion. He then put the resolution in the usual way, and declared it carried unanimously. Continuing, he said: Gentlemen, that closes the business of the meeting; and just let me add that I should have liked to see more shareholders here to-day. The Directors like encouragement as well as the staff, and, although we like the people who are away to repose confidence in us, at the same time it is far more satisfactory to the Directors to see the shareholders come to the meeting.

Mr. GRIFFITH: May I be permitted to propose a vote of thanks to our able Chairman and his colleagues? I think that the absence of our fellow-shareholders is an argument in favour of their confidence in the Directors. If they take this report in their hands they can certainly

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have no objection to offer to the management. I think that the remarks that have been made by the Chairman tend to encourage those who are here in regard to our prospects. It is most satisfactory to find that so bold an attempt to promote the interests of the commercial world as reducing the tariff from 9s. 4d. to 4s. has been satisfactory as far as it has gone. I am glad to find such progress, but, on the other hand, I regret that our Indian and China fellow subjects are not quite so ready to avail themselves of the great advantages offered to them by the Company. I think it is only by telegraphy that we can maintain our position in banking and commerce. You have heard the interesting speech which has been delivered by the Chairman, and you have the Directors' report; and I think that you will all agree that our thanks ought to be tendered to Sir John Pender and his colleagues.

Captain LEWIS: I have much pleasure in seconding the motion, and I am glad to see the Chairman looking so well.

The resolution was carried unanimously.

The CHAIRMAN: I am very much obliged to you on behalf of my colleagues and myself for this renewed expression of your confidence in us. I can only say this, that as long as we continue to be in such perfect touch with our shareholders—such a united body—I think we cannot fail to command success. At all events, if success can be gained by good intentions, your Board will be sure of achieving it.

The proceedings then terminated.

The Brazilian Submarine Telegraph Company (Limited).

The thirty sixth ordinary general meeting of the shareholders of this Company was held at Winchester House, Old Broad-street, on Wednesday last, under the presidency of Sir James Anderson.

The SECRETARY (Mr. Richard Collett) read the notice convening the meeting and the minutes of the last meeting, and the report was taken as read.

The CHAIRMAN: In the remarks I am about to make I do not know whether you will regard them as discouraging or otherwise, but I felt at our meeting six months ago that I ought to call your attention to an active competition which was being created, and now I feel that I must not keep back anything you ought to know, or give a colouring, good or bad, to the facts of our position. I shall therefore read the remarks I have prepared, conscious of my responsibility in view of what may be a turning point in our history. I need only call your attention to a few leading items in the report and balance-sheet. We have increased our agencies by establishing agencies, especially at Buenos Ayres—a most important agency, which accounts for the greater part of the increase of £500 under this head, Abstract B, as compared with the corresponding period of 1890, and I anticipate we shall yet be compelled to add to this amount for other agencies. The salaries are £218 more, necessitated by the increase of work; and we must further add to this amount when we establish duplex, a few weeks hence. For laying on water to our Madeira station we have had to pay £187. Travelling expenses, stationery, and sundry items are larger in consequence of dealing with an increased and abnormal revenue. But as a set off there has been some saving in the expenditure, as follows:—The electrical expenses show a decrease of £361. The Sanatorium at St. Vincent, which cost £600 last year, does not appear again, and the cost of repairs to buildings has been £395 less, showing altogether a reduction in the expenditure of £1,350, so that there is in the aggregate a decrease of £83 upon the working expenses; while there has been an increase in the revenue of £33,920, and the gross revenue for the half-year is £158,000. In the report we have properly stated that this revenue is exceptional, and largely due to disturbances in South America with which we are all familiar; and I may here call your attention to the fact that the current half-year will have to bear the cost of a repair near Pernambuco, referred to in paragraph 6 of our report, amounting probably to at least £10,000, and the cost of duplexing our cables about £6,000. This will explain the wisdom of carrying forward so large a sum. There is also in the balance-sheet under review a sum of £11,200 which has been long in dispute. We cannot of course look forward to the recurrence of such an item in our favour. Neither can we hope, and we ought not to hope, for a recurrence of such a series of disastrous revolutions as have augmented our receipts abnormally for the last twelve months. We must, in fact, be prepared to anticipate a period in which the cry for economy and retrenchment both in political and commercial circles will be such as must reduce our revenue. Nor is this all that can and has already come upon us. You may remember that when I had the honour of presiding at your last meeting I pointed out upon the map the various opposing lines which were being promoted. Since then one line—the French Antilles cable, up to the present extending from Hayti to the vicinity of Para, a short distance from the terminal station of the lines of our partners, the Western and Brazilian Company—has been completed and opened for traffic. Up to the present time this rival line has not done us much harm, but they will no doubt learn to take some traffic. I do not know if they intend to lower the tariff, and we do not yet see that it is our policy or in your interests that we should initiate a war of tariffs. The termination of the civil war in Chili has again brought into active rivalry and competition for traffic what is called the Central American Telegraph Company. We have had to count with this active competition for a good number of years, and we did not suffer much. As to the amount of injury they can do us in the future, a great deal depends upon the question of their adopting an unremunerative tariff, and extending their cables to the east coast. There is still another rival cable from Senegal to Pernambuco, which we are assured will be laid in about six months, and which I pointed out to you on the map at our last meeting. The main injury this rival line will do us will also depend upon the tariff they adopt. This, however, we can say with certainty, that whatever tariff any of these lines may adopt, we shall adopt the same, or lower; and beyond all controversy each and all of our rivals will regret a war of rates more than we shall. We have no right to complain that promoters and contractors should engage in such enterprises if their judgment cannot see anything better for the exercise of their energies and the expenditure of their money than following where we have led, and for a good many years struggled on without any increase of revenue, bearing what is commonly called the heat and burden of the day; paying only 5 per cent., with an insufficient reserve for at least five years. It is a common saying that imitation is the sincerest form of flattery; and if we were vain we might take credit for far-seeing sagacity and ability in projecting the first cable to Brazil; but as it will do no good to your interests, and we are not vain, we shall not ask any consideration upon that score. We must let sentiment alone. We have seen the possibility of these lines coming into existence for years. There was no way of staving them off otherwise than by paying very large sums for concessions, and laying unnecessary cables, which would have depleted your reserve years ago, with no profitable result whatever. We have left to others to try this experiment, and we have kept our money, and you have had your dividends averaging for the 17 years a trifle over 6 per cent., and now we must look on and see how far this lavish expenditure has been judicious, and study how far we can best meet the competition. We adopted the policy of increasing your reserve and laying another cable out of that reserve, thereby increasing our carrying capacity without increasing our capital; so that with a large carrying capacity and a moderate capital we are in the position of carrying a large traffic which a reduced tariff may happily develope. This Company has duplicate cables throughout. Our partners, the Western and Brazilian, have duplicated their system over their most important sections, and both Companies are establishing duplex over every section of their cables. We think these provisions, with our experience, should give us a service that will secure us a large share of the traffic. Then I may here say that we are not without resources to carry our energies into the pastures of our rivals; but I must not be too explicit upon this point at present. You may be sure that your Directors are not neglecting any and every feature which bears upon united and harmonious working with our partners, and extending our efforts whenever we can usefully do so. Of course I have something in my mind when I say that, but I shall not say anything more explicit about it now. I know I am speaking rather vaguely—you must trust us. The duplex will cost us money—we shall need a larger staff; everything we now do, even to hold our own, will cost us money, and I personally should be willing to do something that will cost us some pecuniary sacrifice to carry out extensions; but we have reached a stage in our existence when we cannot halt, we need not lead, and run away we shall not. I congratulate you, therefore, that, besides paying you on this occasion a good dividend and a large bonus, we are carrying a good sum to our reserve, not too much, however, when you consider that we have the maintenance and the life of two cables about 7,365 miles in length to provide for. The first duty of your Directors is to secure the maintenance of your property, and I am glad that the duplication of our cable is complete. Your reserve is a substantial amount, and we are as ready for the fray, if fray it must be, as any of our rivals, who have, so far, only single cables. I am not going to boast—there is an old saying, and you know where it is written, "Let not him that girdeth on his harness boast himself as he that putteth it off." We have for years seen the probability of this competition, and I think it only fair to warn you that we must not expect the continuance of an 8 per cent. dividend. We must spend money to meet negotiations which are daily engaging our attention. We must be prepared for a falling off in our revenues, whether the threatened tariff is inaugurated or not; and we must, in short, keep all the money we can in our reserve. It is altogether in your best interests that this should be done. At the same time we do not stand alone. The Globe Telegraph Company, our partners, the Western and Brazilian, and the Eastern Telegraph Company, and some others, are deeply interested in our success. Now, gentlemen, this is the second time I have told you this story. The use of the telegraph is progressing; every year seems to show a moderate increase over the general system of international telegraphy, not always on every section, but sometimes in one direction, sometimes in another, alternating and gradually pervading the whole system. This rivalry may prove to be a blessing in disguise; but, without pretending to prophecy, some of our rivals, in my opinion, will have to wait longer for their share of the blessing than we shall. I do not take a desponding view of our future, but it would be wrong on my part not to tell you as fully as I may the nature of our immediate prospects. The more I reflect upon it the more am I convinced we were right in not expending large sums of your money upon acquiring concessions and laying cables years before they were needed, neither do I dread a reduced tariff: but whenever it comes it is certain that for some years it must yield a reduced revenue. Since 1876 we have from time to time made reductions varying according to locality and destination from 33 to 57 per cent. of the original tariff, and we should in all probability have again reduced the tariff before this time but for the rival cables that we saw springing up. At present, however, we are, we think, justified in pausing and waiting for our rivals to take the first step if they intend doing so; a reduction of tariff on our part at this moment would be a deliberate throwing away of money, and it would not stop any of our rivals from promoting their schemes. Still further upon the assumption, and it is only an assumption, that a reduction of the tariff, if substantially large, would increase the traffic, and temporarily retard our rivals with their single cables; it is certain that pending this growth of traffic we should be the losers, and that as soon as this growth became apparent our rivals would certainly rush on as they are doing at present. So that we should have borne all the loss of the initiation of a reduced tariff with no doubt some increase of traffic, only to have the increasing traffic shared with competitors. These and

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other points are subjects of daily consideration with your Directors, and I feel that I ought not to add another word as to our policy or plans at this meeting. I now move—

"*That the report of the Directors and the accounts to June 30, 1891, now submitted, be approved and adopted, and that a dividend be now declared of 1s. per share (making, with the interim dividends already paid, a total dividend of 6 per cent. for the year ended June 30, 1891), and also a bonus of 4s. per share in respect of the profits for the year ended June 30, 1891, the said dividend and bonus to be respectively free of income tax.*"

Mr. FREDERICK YOULE seconded the motion.

Dr. TREWHELLA asked when the Company's monopoly ceased.

The CHAIRMAN replied that it would cease next year, but although they had protested the Brazilian Government had given another concession.

Dr. TREWHELLA: But it cannot come into operation, I presume?

The CHAIRMAN: Oh, yes, whenever they like. What do Governments care for us? We are merchants, and we shall have to fight our competitors. He then put the resolution, which was carried unanimously.

On the motion of the CHAIRMAN, seconded by Mr. J. DENISON PENDER, the Hon. W. St. John F. Brodrick, M.P., was re-elected to his seat at the Board, as was also Lord Sackville A. Cecil, on the motion of the CHAIRMAN, seconded by Mr. THOMAS FULLER (tho Managing Director).

Dr. TREWHELLA then proposed the re-election of the auditors, Mr. Henry Dever and Mr. John Gane.

Mr. HAWKES seconded the motion, which was unanimously adopted.

Dr. TREWHELLA then proposed a cordial vote of thanks to the Chairman and the Directors for their vigilant watchfulness of the shareholders' interests. He had observed in nearly everything that the Chairman had said a great deal of caution, and he thought that this must commend itself to them all. He had been connected with the Company from the very beginning, having been one of the original allottees, and he thought they were in very excellent hands.

Mr. HAWKES seconded the motion, which was unanimously adopted.

The CHAIRMAN, in acknowledging the vote, assured the shareholders that they were doing all they could to maintain the interests of the Company.

The proceedings then terminated.

The City of London Electric Lighting (Pioneer) Company (Limited).

An extraordinary general meeting of the City of London Electric Lighting (Pioneer) Company (Limited) was held at Winchester House, Old Broad-street, on Tuesday last, under the presidency of the Hon. Alan Charteris, when the subjoined resolution, which was passed at the extraordinary general meeting of the Company held on September 30, was submitted for confirmation as a special resolution—

"*That the Company be wound up voluntarily.*"

Mr. J. C. BULL read the notice calling the meeting and the minutes of the last meeting.

Mr. RONALD H. SAVORY proposed—

"*That the resolution passed at the extraordinary general meeting of the Company held on September 30th, namely, that the Company be wound up voluntarily, be confirmed,*"

which was seconded by Mr. W. H. KEED, and carried.

Mr. RONALD H. SAVORY proposed—

"*That the Hon. Alan Charteris and Mr. J. Cecil Bull be, and are hereby, appointed liquidators of the Company for the purpose of such winding up, at a remuneration of 50 guineas each,*"

which was seconded by Mr. J. A. KELMAN, and carried.

The proceedings then terminated.

NEW COMPANIES, STATUTORY RETURNS, &c.

BRITISH MEXICAN ESTATE COMPANY (LIMITED).—This Company was registered on October 14, 1891, with a capital of £200,000, divided into 39,800 shares of £5 each, and 5,000 shares of 5s. each, by T. Cresswell, Stanmore Villa, Hither Green, Lewisham, S.E. As the name implies, the objects are to acquire and develope estates in Mexico, and to construct, execute, equip, work, and control railways, tramways, docks, electric light, heat, and power works, telephones, telegraphs, &c.

MANCHESTER SHIP CANAL, PONTOONS, AND DRY DOCKS COMPANY (LIMITED).—The above Company was registered on October 14, 1891, with a capital of £300,000 in £10 shares, by C. Doubble, 14, Serjeants'-inn, Temple, E.C., while their main objects are to construct dock and shipbuilding yards on the Manchester Ship Canal. One of the articles in the Memorandum of Association reads, "To carry on business as electrical engineers and suppliers of electricity for the purposes of heat, light, motive power, or otherwise." The first Directors are G. Renwick, T. Bell, J. T. Eltringham, and A. Taylor.

C. MEADOWS AND COMPANY (LIMITED).—This Company was registered on October 16th, 1891, with a capital of £20,000 in £10 shares, by Franklin, Wild and Co., 14 and 15, Broad-street-avenue, E.C. The objects are to acquire and carry on the business of C. Meadows and Co., forgers, roller and steel manufacturers, mechanical and electrical engineers, brassfounders, machinists, &c., at Tinsley Park Works, near Sheffield. The first Directors are C. Meadows, Park-lane, Broomhall Park, Sheffield, and A. Senior, of 7, Parkers'-road, Sheffield, the former being the Chairman and Managing Director. Office: Tinsley Park Works, Tinsley Park-road, Sheffield.

SERPOLLET SYNDICATE (LIMITED).—This Company was registered on the 15th October, 1891, with a capital of £2,000, in £1 shares, by T. F. Wild, 15, Broad-street-avenue, E.C. The objects are to acquire certain patents for the generation of steam and the regulation of the supply thereof to motors, to design and manufacture all kinds of steam boilers, including those of the Serpollet system, and all accessories thereto, and to carry on the business of mechanical and electrical engineers, brassfounders, metalworkers, boilermakers, millwrights, &c. The regulations of Table A mainly apply. Registered office: 15, Broad-street-avenue E.C.

AURORA ELECTRIC LIGHTING AND DISTRIBUTION COMPANY (LTD.).—The statutory return of the above Company, made up to October 12, 1891, was filed on the following day. The Company, which was registered on May 29, 1891, has a nominal capital of £25,000 in £1 shares; 35 shares have been taken up, the full amount called, and all calls paid. The original subscribers are the only shareholders. No agreement has as yet been filed for the taking over of any business. Registered office: 54, New Broad-street, London, E.C.

BOURNEMOUTH AND DISTRICT ELECTRIC SUPPLY COMPANY (LTD.).—The statutory return of the above-named Company, made up to October 10, 1891, was filed on the 15th following. The Company which was registered on June 1, 1891, to take over the businesses of supplying Bournemouth and district with electricity, carried on by the Brush Electrical Engineering Company (Limited), has a nominal capital of £50,000, in £5 shares. 5,725 shares have been taken up, and upon 2,570 £3 per share has been called, and £7,271 out of £7,710 paid. The remaining 3,155 shares have been issued to the Brush Electrical Engineering Company (Limited) as fully paid. Of the 2,570 shares 435 are taken up by the Brush Electrical Engineering Company (Limited), 1,741 by the Electric and General Investment Company (Limited), of 1, Great Winchester-street E.C.; and the remainder taken up locally. Office: Observer-chambers Albert-road, Bournemouth.

MAXIM-WESTON ELECTRIC COMPANY (LIMITED).—At an extraordinary general meeting of the above-named Company, duly convened and held at Winchester House, Old Broad-street, in the City of London, on Thursday, August 7, 1890, the following extraordinary resolution was duly passed:—"That it has been proved to the satisfaction of this meeting that the Company cannot by reason of its liabilities continue its business, and that it is advisable to wind up the same accordingly voluntarily." And at the same meeting John Marks, Esq., of 113, Great Russell-street, Bloomsbury, in the County of Middlesex, auctioneer, and James Hodgson, Esq., of 19, Queenhithe, in the City of London, paper merchant, were appointed joint liquidators for the purposes of such winding-up. (Filed on October 17, 1891).—This Company was registered on January 17, 1889, with a capital of £75,000, divided into 500,000 shares of 3s. each, to acquire the business and property, and to undertake the liabilities of the Maxim-Weston Electric Company (Limited), then in liquidation, the Directors being Messrs. J. Marks, J. G. Couchman, G. H. Hildyard, J. M. Klenck, and L. Swaby. At the time of the statutory return (May 30, 1889), 261,886 shares had been taken up, upon all of which 2s. per share had been considered as paid, while a call of 6d. per share had been made, resulting in the payment of £6,433. 0s. 6d., leaving £114. 2s. 6d. unpaid. At the time of the first annual return (May 23, 1890) 269,696 shares had been taken up, a similar sum being considered as paid, while a call of 1s. per share had been made. Office: 55, Victoria-street, Westminster, S.W.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).—The traffic receipts for the week ended October 16th were £4,461.

CITY AND SOUTH LONDON RAILWAY COMPANY.—The traffic receipts of this Company for the week ended October 18th amounted to £794; aggregate receipts for half-year to date, £11,205.

COUNCIL BLUFFS (IOWA), U.S.A.—The coupons due November 1st prox. in New York, on Council Bluffs (Iowa), Gas and Electric Light Six per Cent. First Mortgage Gold Bonds, numbered from 1 to 50 inclusive, will be paid by the City Bank (Limited), at the exchange of $4·85 per £, on and after October 20th. The coupons must be left three clears days for examination.

ELECTRIC ARMS AND AMMUNITION SYNDICATE (LIMITED).—The adjourned petition for the winding up of this Company was heard before Mr. Justice Jeune on Wednesday. Mr. Marten, Q.C., and Mr. Smith for the petitioners, submitted that the substratum of the Company was gone, and that it ought to be wound up; but Mr. Justice Jeune, without calling on Mr. Millar, Q.C. and Mr. McLaren said that, having regard to the statement of Dr. Fleming and to the letter of Major Walker, the Chairman of the Company, he did not consider that the Petitioners had made out their case, nor did he consider that the time had yet arrived for winding up the Company, and therefore he dismissed the petition with costs.

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NATIONAL ELECTRIC SUPPLY COMPANY (LIMITED).—The prospectus of this Company has just been issued. The capital is £100,000, in £5 shares, of which 100 are founders' shares. £20,000 has already been applied for by the Directors and their friends, and the present issue is 12,000 ordinary shares. Applicants for 120 ordinary shares are entitled, on allotment, to one founders' share at par value. The founders' shares are entitled to one-third of the net profit, after payment of 7 per cent. on the ordinary shares, which are entitled to the remaining two-thirds. The Company has obtained a provisional order for lighting by electricity the whole of the municipal borough of Preston, where a temporary installation has been in operation by the Company for the past six months, the success of which has determined the Company to put down a permanent installation. The system adopted is the low tension, and the wires will all be underground. A contract has been entered into with Messrs. Latimer Clark, Muirhead, and Co. (Limited) for carrying out the installation; and a convenient site has been secured for the central station. Mr. C. H. Cobbold is the Chairman of the Board; the Engineer and Manager is Mr. Fred. F. Bennett, M.I.E.E.; and the Secretary (*pro tem.*) is Mr. Titus Thorp, with offices at Victoria-buildings, Preston. The list of subscriptions will close on or before Thursday next, the 29th inst.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended October 16th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,535.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Oct. 14.		Price Wednesday, Oct. 21.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Oct. 21.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS.								
£1,300,980	Stock	12/0	Anglo-American ..... xd	48½	49½	48½	49½	5 1 0	Jan., Apr., July, Oct.	48½	48
£2,849,510	Stock	24/0	Do. Preferred ..... xd	87⅞	88½	87	88	5 16 6	" "	87⅞	85⅝
£2,849,510	Stock	5/0	Do. Deferred	12⅝	13⅜	12¾	13½	..	.. ..	13 1/16	12⅝
£250,000	100	4%	African Direct, Telegraph 4% Debentures	99	102	100	103	3 17 8	January and July ..	..	..
130,000	£10	5/0	Brazilian Submarine	12	12½	12	12½	6 16 0	Mar., June, Oct., Dec.	12½	12 1/16
£69,200	£100	5%	Do. 5 per Cent. Bonds	99	102	100	103	4 17 1	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103	107	103	107	4 13 6	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	125	130	125	130	5 7 8	April and October ..	129½	129
16,000	10	8/0	Cuba Submarine	10	11	10	11	7 5 6	February and August	..	..
6,000	10	10%	Do. Preference 10%	17	18	17	18	5 11 1	" "	..	..
12,931	5	2/0	Direct Spanish (£4 paid)	3½	4	3½	4	7 0 0	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9½	10½	9½	10½	4 15 3	" "	..	..
60,710	20	3/6	Direct United States ..... xd	11	11½	10⅝	11½	6 6 0	Jan., Apr., July, Oct.	11 1/16	10⅞
400,000	10	5/6	Eastern ..... xd	14¼	14½	14¼	14½	4 9 8	" "	14⅝	14⅜
70,000	10	6%	Do. 6 per Cent. Preference ..... xd	15	15½	15	15½	3 17 5	" "	15 7/16	..
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock.....	107	110	108	111	3 12 1	May and November	110½	108¼
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 10 11	February & August	..	..
250,000	10	2/6	Eastern Extension ..... xd	15	15¼	15 1/16	15⅜	4 11 1	Jan., Apr., July, Oct.	15 3/16	15
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock	106	109	106	109	3 13 5	February & August	..	..
£85,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	104	107	104	107	4 13 6	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor. Deb..1900 ..	102	105	102	105	4 15 3	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	99	102	99	102	3 18 5	January and August	..	..
180,227	10	4/6	Globe Telegraph and Trust ..... xd	9⅜	10	9⅝	9⅞	5 8 10	Jan., Apr., July, Oct.	9⅞	9 1/16
180,042	10	6%	Do. 6 per Cent. Preference	14⅜	15⅛	14⅜	15	4 0 0	" "	15	14⅜
150,000	10	5/0	Great Northern	18⅜	19¼	18⅜	19¼	4 8 4	Jan., April, and July	19	18 1/16
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105	108	105	108	4 12 7	March & September	105½	..
17,000	25	37/6	Indo-European	41	43	41	43	5 13 3	May and November	43	..
38,348	10	5/0	London Platino-Brazilian	6½	7½	6½	7½	6 0 0	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105	108	105	108	5 11 1	March & September	103	..
9,000	8	4/0	Reuter's	8	8½	8	8½	4 14 1	April and October..	..	..
3,381	£100 Cert.	£1	Submarine Cables Trust 6% .....April coupon, £2	120	125	117	122	4 18 4	" "	118½	..
15,609	10	6/0	West African Telegraph	7½	8½	7½	8½	5 17 8	January and July ..	..	..
£281,400	100	5%	Do. 5 per Cent. Debentures	97	100	98	101	4 19 0	March & September	99	..
30,000	10	2/0	West Coast of America	3½	4	3½	4	..	January and July ..	..	..
£150,000	100	8%	Do. Debentures 8% 1902	98	103	98	103	7 15 4	June and December	..	..
88,321	10	9d.	West India and Panama	1⅛	1⅜	1	1¼	..	..	1 1/16	1
34,563	10	6%	Do. 6 per Cent. 1st Preference	8½	9½	8½	9	6 13 4	May and November	9¼	8¾
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	7½	8½	7	8	7 10 0	" "	..	..
61,683	15	9/0	Western and Brazilian	10¾	11¼	10¾	11¼	6 13 4	" "	11¼	11
30,364	7½	1/6	Do 5 per Cent. Cumulative Preferred	6½	7	6½	7	5 7 3	—	7	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	4¼	4¾	4¼	4¾	..	..	4¾	..
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103	106	103	106	5 13 2	February & August	105¼	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103	106	103	106	5 13 2	" "	.	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	120	125	120	125	5 12 0	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	98	102	98	102	5 17 8	March & September	..	..
			TELEPHONES.								
224,850	14/0	0/5½	Consolidated Telephone Const. & Maintenance...	7/8	9/8	7/8	9/8	..	May and November	⅛	..
220,000	£1	4·76d.	Oriental (11s. paid)	1/8	1/8	1/8	1/8	6 3 11	Yearly	..	..
438,984	5	3/6	National	4¼	4⅜	4⅜	4⅝	6 9 9	June and December	4 9/16	4⅜
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½	12¾	12½	13	4 12 4	" "	12 1/16	12½
15,000	10	6%	Do 6 per Cent. Cumulative 2nd Pref. (£8 pd) .	12	13	12	13	3 14 1	" "	..	..
350,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd)	105	107	105	107	4 4 1	..	106¾	106
58,000	5	1/0	United River Plate	2	3	2	3	.	January and July ..	..	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85	95	85	95	5 5 8	—	..	..
			ELECTRICITY SUPPLY COMPANIES.								
1,000	£10	..	City of London Electric Lighting (£4 paid, £10 Sh.)	4⅛	4⅜	4⅛	4¼	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	..	..	..	..	..	..	..	..
5,322	£5	..	House to House Electric	4½	5	4½	5	..	..	..	..
30,000	£5	..	Liverpool Electric Supply (£3 paid)	4⅝	5⅛	3⅝	4⅛	..	..	..	..
111,000	5	..	London Electric Supply	1⅝	2⅛	1⅝	2⅛	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	9¾	10⅛	9¾	10⅛	..	..	10⅛	..
6,318	10	..	Notting Hill Electric Lighting (£8 paid).....	3½	4½	5½	6½	..	..	..	..
7,730	£5	3/6	St. James' and Pall Mall	7⅜	8⅛	8	8½	..	..	8⅝	8 1/16
..	..	7%	Do. 7% Preference	7	7½	7	7½	..	..	7⅝	7½
42,853	5	..	Westminster Electric Supply (£5 paid)	5¾	6⅛	5⅝	6	..	..	6	5⅝
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
£2,850	10	..	Blackpool Electric Tramway	..	..	..	..	..	..	..	..
77,978	3	1/8	Brush Electrical Engineering	3⅛	3⅜	3¼	3½	5 2 9	..	3⅜	3 1/16
69,996	2	6%	Do. 6 per Cent. Preference	1⅝	2⅛	2	2¼	5 6 8	June and December	2⅛	2
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5	5½	5	5½	6 7 3	January and July ..	..	..
17,130	5	..	Edison and Swan United	..	..	..	..	..	..	..	..
45,000	10	6%	Electric Construction	6¾	7¼	6¾	7¼	..	—	7⅜	6 15/16
70,000	2	10/0	Elmore's Patent Copper Depositing	3⅜	3¾	3¾	3¾	..	—	3¾	3 1/16
20,000	5	..	Fowler-Waring Cables (£4 paid).....	2	3	2	3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works ..	20	21	20	21	4 15 3	February & August	20⅜	20⅛
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	104	102	104	4 6 7	March & September	..	..
11,334	£10	6/1	International Okonite Limited Ordinary	7	8	6	7	..	..	..	..
11,334	£10	5/0	Do. Preference ..... xd	9	9½	8¾	9¼	8 13 0	..	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	⅛	⅜	⅛	⅜	..	..	..	..
78,949	5	2/1½	Swan United (£3. 10s. paid)	5	5½	5	5½	6 7 5	May and November	5⅝	5½
37,350	12	12/0	Telegraph Construction and Maintenance	42	44	42	44	5 9 3	March and July.....	43½	42½
50,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	102	104	102	105	4 15 3	January and July ..	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£2. 10s. paid) ..	..		2⅛	2⅜	..	..	..	..
—	£5	..	Do. Preference (fully paid).....	..		3¾	4	..	..	..	..
			RAILWAYS.								
50,000	£10	..	City and South London Railw			2		—	—	—	—

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THE ELECTRICIAN:

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NOTES.

The result of the introduction of the trolley line system of electric traction into this country will be watched with interest by electrical engineers. It is one thing to disfigure the important thoroughfares of a town with the overhead conductor, or, still worse, with the network of suspending wires which are generally required at each corner or sharp curve; and it is another thing to place an outlying suburb in connection with the busy part of a city by a tram line passing through the frequently squalid districts which intervene. Inhabitants of those towns which can boast of greater architectural features than can be found on the route of the new line at Leeds may be thankful that the experiment is being tried there. No one who is familiar with the beautiful country to the north of that town would like to see the complicated insulators and sprawling "frogs" hung up in the sky, as incidents in the foreground of an abbey or a dale. The experiment may be welcomed by our makers of traction machinery, since, if it gives satisfaction, they have only to go forward and erect such lines wherever they may be wanted. If the conditions of this contract are no better than those which were being negotiated a short time ago, no English manufacturer would have cared to undertake it, and thus an opportunity has been afforded them of standing on one side, and seeing the specimen of the American work which this line is an attempt to introduce.

The German electrical instruments which are described by our Frankfort correspondent in the present issue strike the English eye as being in a somewhat undeveloped condition; and yet we are fully aware of the strides which electrical engineering has recently made in that country, the high aim and thoroughness with which it is carried out, and the accuracy which everyone expects to find in German scientific work. The name of Kohlrausch is or should be familiar to all students of physics, many of whom are greatly indebted to the well known book by that author on physical measurements. The Kohlrausch ammeter is of a type which has appeared on several occasions. Prof. Blyth spent a good deal of pains upon it. Profs. Ayrton and Perry reduced the displacement of the core to a minimum; and Mr. A. Miller was working on a core floating in mercury at the time of the Inventions Exhibition, magnifying the motion by the displacement of liquid in a fine glass tube. Thin as the tube of iron may be, we fail to see how the serious errors which are caused by the presence of iron can be avoided. In the best English instruments the iron is reduced to a little morsel of wire, and every effort has been made to correct the errors which even these few grains produce. The cores of some American solenoid instruments run into ounces.

A recording voltmeter is not a very difficult instrument to make, for the range need not be great. The elimination of the friction of the pen is one of the chief difficulties. But a recording ammeter is a very different matter, for it is necessary that it shall go back to a definite zero, besides working correctly throughout its range. The important point, however, is the production of a uniform scale, without which all measurements of areas are impracticable. We observe in the illustration of the Hartmann and Braun instrument (Fig. 3, p. 717), that the scale does not appear to be uniform. It would be easy to criticise the motor-meter and the magnetic cutout, but it is very possible that they give satisfaction, so we only call the attention of English manufacturers to them.

It is fortunate for this country and for its overgrown capital that our progress in other directions has been more rapid than it has been in regard to the telephone. Even if we leave out such apparently phenomenally talkative countries as Sweden, Norway, and Luxembourg, Great Britain figures very badly on a list which will be found in our "Notes" column. In Germany it seems over 100 individuals per 100,000 inhabitants find the telephone within their reach; in Great Britain less than 60 can afford it. In Berlin more than 11 citizens per thousand use the telephone; while in London the figure is 1·5. The telephone may not be an unqualified blessing, but these comparisons show that there is something rotten in this respect in the state of Denmark—or rather England.

Mr. Bayly's letter to *The Times* of Wednesday again draws attention to the pressing need for telegraphic communication around our coast, a subject which the Associated Chambers of Commerce are constantly urging upon the Government, but apparently without much encouragement. This time Mr. Bayly tells a pathetic story of the wreck of the "Marana," one of four ships totally lost during the blizzard storm last March, within a short distance of the Start lighthouse, and the drowning of 25 of her crew, owing to there being no electric connection with the Prawle coastguard station. What is true

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of that part of the coast is equally true of many other points, and it is scandalous that preventive measures are so long delayed simply because no single department of the State cares to incur the expense. If these lightships, lighthouses, and coast-guard stations belonged to some railway company the obligation to employ them humanely for the saving of life, as well as commercially for the protection of property, would have been sternly enforced long ago. This is distinctly a national question, and the expense of establishing an electric girdle round the British Isles should be a charge upon national revenue.

A few months ago we alluded to some experiments of Mr. F. J. Smith, who had examined a variety of electro-magnets with the special object of finding the form most suitable for use in chronographs. It now appears, from an article contributed by the same investigator to the October number of the *Philosophical Magazine*, that the best kind of electro-magnet for this purpose consists simply of a twisted iron wire used as the core of a long solenoid. It has long been known that under certain circumstances twisted iron wires untwist when magnetised in the direction of their length; but the fact, like a host of others connected with the science of magnetism, has not hitherto been used for any theoretical or practical purpose. It occurred to Mr. Smith that a light pointer attached to one end of the wire could usefully indicate the flow of current in a surrounding solenoid, and on investigation it was found that such a pointer responds to sudden changes of current more rapidly than is the case with any other form of electro-magnet. The motion of the pointer is very slight, but this is no disadvantage in the stylus of a chronograph, where the great thing wanted is exact coincidence in time between the motion of the pointer and the alteration of the current.

The investigation gave rise incidentally to several interesting points. Wiedemann, who first described the phenomenon, examined twisted wires subjected to stress; and found that magnetisation caused them to untwist. Mr. Smith used wires to which he had given a permanent torsional set, but without exposing them to the influence of longitudinal pull. The magnetic forces he employed were much greater than those used by Wiedemann, and under these circumstances the wire, instead of untwisting, increases its twist when magnetised, and the torsion increases with the strength of the magnetic field. A maximum is, however, reached when the field is about 1,000 times as strong as that due to the earth, and after this the wire commences to untwist.

Our attention was recently called to a small point in connection with the law of electric lighting about which a mistake might easily be made. According to Section 4 Sub-Section 1 of the Electric Lighting Act of 1882, no Provisional Order may be granted unless notice of the intention to apply for it has been served on the Local Authority of the district on or before the 1st day of July in the year in which application is made. On the other hand, a hasty perusal of Rule V. of the Board of Trade Rules (August, 1890), relating to the mode of procedure to be adopted by intending applicants for Orders and licences, would lead one to suppose that this all-powerful Government department had over-ridden the Principal Act, and altered the above mentioned date to 1st November. As a matter of fact, however, the rule in question relates only to applications affecting a district in which there are already statutory electric light undertakings. The rule requires notice to be given to all such "undertakers" within the area, whether Local Authorities or otherwise, and this notice is in addition to that required by the Act itself, to be given to the Local Authority of the district.

The Naval Exhibition, which closed on Saturday last, has been an unqualified success as an Exhibition; that is to say, a place of amusement and mild instruction. Neither the music nor the cuisine were as good as were to be found at the German Exhibition; but the toy warfare and fireworks were thoroughly appreciated. A half-pay Admiral of our acquaintance, though nearly 80 years of age, was very desirous of visiting the Exhibition, as he had never seen a naval engagement. The electric lighting was very satisfactory, although the arc lamps needed an occasional stirring up with a pole. The lighthouse was a feature not only of the Exhibition, but of the metropolis. The light was rather variable—3,000,000 c.p. according to the official account, 500,000 c.p. according to yesterday's *Daily Telegraph*, probably 10,000 c.p. on a photometer. The lesson to be learned by electrical engineers was that an engine-room may be laid with oilcloth and kept as clean as the engineer's office, and the lesson has already borne fruit in more than one central station.

At the moment of going to press we learn that the Leeds Tramway was opened sucessfully by the Mayor, the whole six cars crowded with people being run at once.

"Elektrotechnische Rundschau."—The *Elektrotechnische Rundschau*, which is just entering upon its ninth year of publication, is now appearing twice monthly in a considerably enlarged form.

The Electric Lighting of the New Bankruptcy Courts.—We hear that the electric light is being installed in the new Bankruptcy Court, where it will doubtless be as much at home as it was in the old.

A New Electric Railway Subway.—It is stated that the London and South-Western Railway Company intend to apply next Session for powers to construct an electrical railway in a subway from Waterloo to the City.

Projected Electric Railway between Baden and Voslau.—Negotiations are pending with regard to an electric railway between Baden and Voslau, a distance of about 3 miles. The scheme also includes the lighting of both towns, and the estimated cost is £25,000.

Paddington Vestry.—At the last meeting of this Vestry it was decided that the Works Committee be requested to arrange for a public opening of the electric light installation in the Vestry Hall, the expenses to be met by the subscriptions of the members of the Vestry.

Cable Interruption.—The Great Northern Telegraph Company announce that the Japanese land lines between Hiogo and

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Osaka are interrupted, owing to a severe earthquake which occurred on Wednesday morning last, and which has caused great damage and loss of life.

Lightning.—During the severe thunderstorm last week the lightning struck a blacksmith's shop at Winfarthing (Norfolk). The fire travelled under the thatch, and demolished seven cottages. Two thatched cottages in Little Melton were fired by lightning the same day and gutted.

Alternate Current Curves.—We hear that the apparatus and diagrams illustrating Dr. Fröhlich's beautiful optico-telephonic method of taking periodic curves, which was exhibited by Siemens and Halske at the Frankfort Exhibition, will be shown by Siemens Bros. at the Crystal Palace.

Sheffield.—At the last meeting of the Town Council the sub committee of the Parliamentary Powers Committee recommended that the Corporation should support the application of the Sheffield Telephone Exchange and Electric Lighting Company for a Provisional Order. The recommendation was adopted.

Temperature Coefficients.—Erratum.—Mr. Fuller asks us to make the following corrections in his last week's letter:—$(1+\alpha)^t - m^t$ should read $(1+\alpha)^t + m^t$, where α and m are both constant; also, instead of "but increased more rapidly as the temperature decreased," read, "but *decreased* rapidly with the temperature."

Telephonic Communication with Plymouth Breakwater Fort.—Telephonic communication has now been successfully established between Mount Wise, Devonport, the breakwater fort in Plymouth Sound, and Fort Picklecombe, on the western shore of the harbour. The work has been carried out under great difficulties, owing to the bad weather.

Proposed Electric Tram Line.—The Sedgley, Dudley, and Wolverhampton Tramway Company are about to apply to the Board of Trade and the local authorities for sanction to use electricity in lieu of steam. During the last two years there has been great difficulty in running the engines, owing to the steep gradients at Upper Gornal and Sedgley Hill.

Huddersfield.—At the last meeting of the County Council it was decided to make application to the Local Government Board for permission to borrow the sum of £50,000 for the purpose of electric lighting works, and the Town Clerk was instructed to take the necessary steps in connection with this matter, and also to obtain the approval of the system adopted.

Electric Launches.—The electric launch apparently bids fair to become an indispensable adjunct to every seaside resort, places as wide apart as Paignton, Bray, and Southport each proposing to have a small fleet of them next season. The General Electric Power and Traction Company are, we believe, preparing to place several electric launches on the Manchester Ship Canal.

Glasgow.—At the last quarterly meeting of the Glasgow Chamber of Commerce attention was drawn to the unsatisfactory working of the telephone system on the trunk lines. For a considerable time past, it was said, the service had been giving great dissatisfaction as regarded the working to Edinburgh and Leith, and individual subscribers could get little or no redress.

The Italian Government and the Telephones.—Last year the Italian Government presented a Bill to Parliament for buying up the telephone system of Italy. This Bill was subsequently abandoned, and the Minister of Public Works has since presented to the Chamber of Deputies another one, according to which, if approved, the service of the telephones is to be carried on by private enterprise for twenty-five years.

The City and South London Railway.—The Directors of the City and South London Railway have arranged to issue season tickets. They have further decided to increase the fares from 2d. to 3d. between the hours of 8 and 10 a.m. on and after November 1st. We may remark in this connection that our New York contemporary, the *Electrical World*, has in its issue of October 24th by far the best view we have yet seen of this Company's generating station. The illustration is accompanied by an excellent and critical description of the line by Mr. Carl Hering.

A New Dry Cell.—A new dry cell, brought out by Herr Leo Graef, in Rotterdam, is said to possess a high electromotive force with extremely good recuperative properties. From tests made it appears that a cell on open circuit gives 1·55 volts. On being closed on a 50-ohm circuit for 13 minutes the volts fell to 1·50, but had again risen to 1·54 after four minutes' rest. On external resistances of 10 ω, 5 ω, and 1 ω respectively the volts after 15 minutes fell to 1·41, 1·31, and 0·95; but a four minutes' interval was sufficient in the last case to raise them again to 1·30.

The Telegraph Line to Gilgit (Kashmir).—The wire to Gilgit is to be an underground one. In fact, any system on posts of the ordinary character would, says the *Indian Engineer*, never stand the winter snows. Even supposing that the wire could be sufficiently raised not to be covered by the drifts—and this, we imagine, could only be done by having a staff in the cold weather to watch how and where the snow principally drifted—the posts would not stand the pressure unless they were placed firmly on cairns of stone. It is calculated that two full working seasons will be needed to carry the telegraph to Gilgit. Both labour and time will be required to lay an underground cable across the mountain ranges covered for seven months in the year with snow.

Worcester.—At the last meeting of the Watch Committee, Mr. Swete, electrical engineer, reported that in accordance with the instructions of the Committee he had canvassed the citizens of Worcester for the purpose of ascertaining the amount of electrical energy that would be required by them in the event of electrical works being established. His canvass had proved that a satisfactory demand for electric light and power existed, in that out of only 388 circulars distributed he received 189 replies taking up lamps or motors equivalent to 13,660 incandescent lamps of 10 c.p. He had but little doubt that if the inquiry were extended an equivalent to 16,000 lamps would be wanted. The report was referred to the Sub-Committee to recommend what should be the next step in the matter.

Cable and Land Line Interruptions and Repairs:

	Date of interruption. 1891.		Date of repair. 1891.
Cape St. Jaques-Thuan An-Haiphong Cables	June 28	.....	Oct. 9.
Foochow-Shanghai Cable	Sept. 2	.....	„ 15.
Saigon-Bangkok Line	„ 18	.....	Sept. 26
Brest-St. Pierre Cable (Anglo-American)	„ 22	.....	Oct. 3
Transandine Line	Oct. 9	.....	„ 9
„ „	„ 14	.....	„ 15
„ „	„ 18	.....	„ 18
St. Thomas-St. Kitts Cable	„ 13	.....	*
Grenada-St. Vincent Cable	„ 13	.....	„ 18
Para-Maranham Cable	„ 17	.....	„ 19
Cayenne-Vizeu Cable	„ 22	.....	*

* Not yet repaired.

The Telegraph across the Kistna River.—On the evening of the 7th September, a Madras paper reports that a daring attempt was made to destroy the telegraph crossing the river Kistna at Bezwada. These crossings, says the *Indian Engineer*, are the longest telegraph "spans" in the world, being something like 1,700 yards in length. There are seven of them across the river from hill to hill; and they are all terminated on stout wooden posts fixed in the rock at the top of the Bezwada and Seetanagram hills, and are protected by wooden houses. At about eight p.m. on the above date these terminals were seen to be in flames. On examination it was found that three out of the seven protection houses were completely burnt, and the terminal posts considerably charred. The heat of the flames destroyed the insulators to which the wires were attached, and the latter fell into the river. It was found that attempts had been made to set fire to all the terminals, but fortunately the fire could not be got to burn, owing perhaps to the strong wind. It is stated to be without doubt a clear case of incendiarism, as matches, charcoal, wood-shavings, and kerosene oil were employed.

"Lightning."—A new weekly journal bearing this name is addressed from Faraday House, Charing Cross-road, to "the great reading public," "householders whose residences are fitted up with electric light," "investors," and others. The "others,"

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by-the-bye, constitute a large proportion of our own readers. Amongst the attractions is a ladies' column, from "Bess" to "My dear May," various prizes, and a City letter, &c. It is difficult to imagine the kind of investor who would give serious attention to advice from such a source. The technical press have regarded descriptions of apparatus from the point of view of the manufacturer and the trade, but *Lightning* will also cater for the "general reader." The attempt does not look more hopeful than the previous ones which have been made to sit between two stools.

The Chicago Exhibition.—A meeting of the Royal Commission was held at the Society of Arts, John-street, Adelphi, on Wednesday afternoon, 21st inst, to receive the report of Mr. James Dredge and Sir Henry Trueman Wood on the result of their visit to Chicago. The report was received, and ordered to be printed, thanks having been voted to the authors. The Commission considered and approved a form of circular to exhibitors, which was ordered to be issued. They decided to appoint the following Committees:—Finance, Fine Arts, Indian, Colonial, Engineering, General Manufactures, Electricity, Agriculture, Mines and Metallurgy, Textile Industries, Science and Education, Transportation; also a committee of ladies to correspond with the ladies' committee at Chicago. They further decided to invite the assistance of Chambers of Commerce as local committees.

The Cables of the Société Française des Télégraphes Sous-Marins:

Santiago (Cuba)—Guantanamo (Cuba)	50·66	knots.
Guantanamo—Môle St. Nicolas (Hayti)	126·76	,,
Môle St. Nicolas—Cape Hayti	96·04	,,
Cape Hayti—Puerto Plata (Dominica)	117·83	,,
Môle St. Nicolas—Port au Prince (Hayti)	124·76	,,
Puerto Plata—Fort de France (Martinique)	787·42	,,
Legoazier (Guadeloupe)—St. Louis (Marie Galante)	19·81	,,
Guadeloupe—Martinique	101·90	,,
St. Pierre (Martinique)—Fort de France (Martinique)	14·86	,,
Martinique—Paramaribo (Dutch Guiana)	777·23	,,
Paramaribo—Cayenne (French Guiana)	257·53	,,
Cayenne—Vizev (Brazil)	662·38	,,
San Domingo—Curaçao	453·47	,,
Curaçao—Guayra (Venezuela)	163·37	,,
Total	3,754·02	,,

The Electric Light at Kimberley.—The Kimberley papers received by the last mail from South Africa record the inauguration of the new electric installation for the lighting of the borough. The installation has been carried out under the direction of the borough electrician, Mr. David A. Bremner, formerly with the Brush Company. The Mayor, who presided at the inaugural ceremony, said that their original installation cost £7,000, and the yearly expense of working it had been £4,500, and yet complaints were constantly arising owing to the erratic nature of the supply of light. At last they were fortunate enough to secure the services of Mr. Bremner, who had come out specially from England to take up the duties of borough electrician. Mr. Bremner's first duty was to report on the state of the installation, and he uncompromisingly condemned the whole thing. This caused them to look on the new electrician as a man of very expensive ideas; but Mr. Bremner carried the day, with the result that they now possessed what was certainly the finest electric lighting plant in the colony. At a meeting of the Borough Council subsequently, a special vote of thanks to Mr. Bremner was passed. The installation consists of 56 arcs.

Lightning Guard for Electric Light Installations.—The latest form of Dr. Lodge's lightning guard, designed for the purpose of filtering lightning out of electric light leads, is being constructed by Messrs. Muirhead and Co., of Cowley-street, Westminster. The current enters at one end of the axis, circulates through two thick wire highly-insulated coils, and leaves by the other end of the axis; but in so doing it has to pass three pairs of brass collars, which clamp between them a square of mica coated with tinfoil, the corners of which come very close to an outer metal case thoroughly connected with the ground. When lightning, therefore, attempts to follow the current, it spits off from one or other of the covers of the first tinfoil to earth, thereby striking a momentary arc, which is destroyed the next instant by the fusion of that cover of tinfoil. The other covers remain ready for a future occasion. We understand that, by the kindness of Major Cardew and Mr. Wimshurst, one of these instruments has been privately tested at the Board of Trade laboratory, and has been found to work exactly as intended. The air gap necessary between the brass collars and the outer case must depend on the voltage of the installation for which it is designed and the length of arc accordingly to be expected. At present it has only been tested up to about 100 volts.

Opening of the Dusseldorf Central Station.—On September 1st Messrs. Schückert and Co., of Nuremberg, completed the municipal electricity works in Düsseldorf, which they had carried out on behalf of the Town Council. Since that day the works have been in regular operation, but it was only on Saturday afternoon last (24th) that the inauguration took place. The Düsseldorf municipality now own the gas, water, and electricity works. There are one principal and three secondary stations. The current from the generating dynamos is used partly to charge the secondary batteries in the sub-stations, and partly to feed the distributing mains simultaneously with the accumulators. The Schückert dynamos give 1,000 amperes at 350 volts. The mains connecting the central with the sub-stations were furnished by Messrs. Felten and Guilleaume, of Mülheim. Two of the sub-stations contain small batteries, whilst in the third two sets of 140 cells, having a total output of 1,000 amperes, are arranged. These storage batteries were provided by the Accumulator Works Company of Hagen, who have undertaken to maintain them for ten years. The generating station has been equipped for the simultaneous supply of 10,000 16-c.p. lamps, and the distributing mains to carry current for 25,000 lamps. Applications equivalent to 15,000 16-c.p. lamps have already been received, and 171 installations, comprising 12,000 lamps, are either already put up or in process of installation.

Telephonic Progress in Europe.—The following are some official statistics as to the number of telephonic subscribers in various European countries at the end of the years 1887 and 1890 respectively:—

	No. of subscribers. 1887.	No. of subscribers. 1890.	No. of subs. per 100,000 inhabitants. 1890.
Sweden	5,705	19,240	400
Switzerland	4,900	9,203	316
Luxembourg	...	653	307
Norway	...	5,110	255
Germany	14,733	49,531	105
Denmark	1,370	1,837	90
Belgium	3,365	5,282	88
Netherlands	2,493	3,363	75
Great Britain	15,114	20,426	58
France	7,175	16,000	41
Spain	594	7,089	40
Italy	8,346	9,183	34
Portugal	350	890	26
Austria-Hungary	3,032	8,153	21
Russia	5,280	6,556	7

The following are some figures relating to the chief European towns:—

	No. of subscribers. 1887.	No. of subscribers. 1890.	No. of subs. per 1,000 inhabitants. 1890.
Luxembourg	291	853	47·4
Geneva	1,376	2,200	30·1
Christiania	1,070	2,500	18·2
Berlin	4,248*	15,000	11·4
Antwerp	1,086	1,500	7·1
Rome	1,835	2,422	6·5
Paris	5,380	10,000	4·2
Milan	1,109	1,213	4·0
Brussels	1,156	1,800	4·0
Madrid	1,242	1,347	2·6
Naples	921	992	1·9
London	3,591	7,000	1·5
Vienna	1,192	1,800	1·3
Barcelona	299	514	1·2
Amsterdam	1,337	(†)	(†)
St. Petersburg	1,500	(†)	(†)

* October, 1885.

† No official statistics have yet been published.

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ELECTROMAGNETIC THEORY.—XVIII.

BY OLIVER HEAVISIDE.

(Continued from page 656.)

§ 95. We may now briefly compare some of the more important formulæ in the two systems. Let us denote quantities in rational units as in the preceding (except that when vector relations are not in question we need not employ special type), and the corresponding quantities in irrational units by the same symbols with the suffix $_i$; thus, q and q_i. Also denote $(4\pi)^{\frac{1}{2}}$ by x.

Let q_i be the irrational charge which repels an equal irrational charge at distance r with the *same* force F as a rational charge q repels an equal charge at the same distance. Then,

$$F = \frac{1}{c}\left(\frac{q}{xr}\right)^2 = \frac{1}{c}\left(\frac{q_i}{r}\right)^2, \quad . \quad . \quad . \quad . \quad (9)$$

Therefore

$$q = xq_i. \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

As regards the ratio of the units, it is sufficient merely to observe that the magnitude of the number expressing a quantity varies inversely as the size of the unit. This applies throughout, so that we need not bring in units at all, but keep to the concretes appearing in formulæ.

By (10) we shall have

$$x = \frac{q}{q_i} = \frac{\rho}{\rho_i} = \frac{\sigma}{\sigma_i} = \frac{D}{D_i} = \frac{C}{C_i}, \quad . \quad . \quad . \quad . \quad (11)$$

if ρ is volume-density of electrification, σ surface density, D displacement, C electric current density (or else the total displacement and current).

Since $D = cE$, and $D_i = cE_i/4\pi$, ... (12)

whilst $D = xD_i$ by (11), we have also

$$x = \frac{E_i}{E} = \frac{A_i}{A} = \frac{V_i}{V} = \frac{e_i}{e} = \frac{P_i}{P}, \quad . \quad . \quad . \quad (13)$$

where A is the time-integral of E, V the line-integral of E, or voltage, e impressed electric force, P electric potential or potential difference.

The permittivity c is the same in both systems. So is the ratio c/c_0 of the permittivity to that of ether, or the specific inductive capacity (electric). The permittance of a unit cube condenser is c, and also $c_i/4\pi$. If S is the permittance of any condenser

$$S_i = x^2 S, \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

and its energy is

$$\tfrac{1}{2}VQ = \tfrac{1}{2}V_iQ_i = \tfrac{1}{2}SV^2 = \tfrac{1}{2}S_iV_i^2, \quad . \quad . \quad (15)$$

if Q is its charge and V its voltage. We also have

$$\tfrac{1}{2}ED = \tfrac{1}{2}E_iD_i = \tfrac{1}{2}cE^2 = \tfrac{1}{2}cE_i^2/4\pi, \quad . \quad . \quad (16)$$

$$\tfrac{1}{2}P\rho = \tfrac{1}{2}P_i\rho_i, \quad . \quad . \quad . \quad . \quad . \quad . \quad (17)$$

$$\tfrac{1}{2}AC = \tfrac{1}{2}A_iC_i, \quad . \quad . \quad . \quad . \quad . \quad . \quad (18)$$

the first and second sets relating to electric energy, the third to magnetic energy.

By Ohm's law

$$V = RC, \quad \text{and} \quad V_i = R_iC_i; \quad . \quad . \quad (19)$$

therefore by (11) and (13)

$$x^2 = \frac{R_i}{R} = \frac{r_i}{r}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (20)$$

where r is resistivity, so that

$$EC = E_iC_i = RC^2 = R_iC_i^2. \quad . \quad . \quad . \quad (21)$$

§ 96. If the repulsion between two magnetic poles m and m is F at distance r, and this is also the repulsion between irrational poles m_i and m_i, we have

$$F = \frac{1}{\mu}\left(\frac{m}{xr}\right)^2 = \frac{1}{\mu}\left(\frac{m_i}{r}\right)^2, \quad . \quad . \quad . \quad . \quad (22)$$

where μ is the inductivity of the medium, common to the two systems, as is likewise μ/μ_0 the ratio of μ is that of the ether, or the permeability. So

$$m = xm_i. \quad . \quad . \quad . \quad . \quad . \quad . \quad (23)$$

Here some discrepancies come in. For

$$B = \mu H, \quad \text{and} \quad B_i = \mu H_i; \quad . \quad . \quad (24)$$

so we have $$x = \frac{m}{m_i} = \frac{H_i}{H} = \frac{B_i}{B} = \frac{L_i}{L} = \frac{M_i}{M} = \frac{\Omega_i}{\Omega} = \frac{h_i}{h}, \quad . \quad (25)$$

where L and M are surface integrals of B or inductances, Ω is magnetic potential or gaussage. If I be intrinsic magnetisation (intensity of), then

$$I = \mu h, \quad \text{and} \quad I_i = \mu h_i/x^2, \quad . \quad . \quad . \quad (26)$$

from which, and by (25), we have

$$I = xI_i. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (27)$$

The equation $\mathbf{B} = \mu\mathbf{H}$, in the sense used by me, expands to

$$\mathbf{B} = \mu(\mathbf{h} + \mathbf{F}), \quad . \quad . \quad . \quad . \quad . \quad . \quad (28)$$

where $\mathbf{h}$ is intrinsic, and $\mathbf{F}$ is the magnetic force of the field. Also

$$\mu = \mu_0(1 + \kappa) = \mu_0(1 + 4\pi\kappa_i), \quad . \quad . \quad (29)$$

so we have, by (28) and (26),

$$\mathbf{B} = \mathbf{I} + \mu_0\mathbf{F} + \mu_0\kappa\mathbf{F}, \quad . \quad . \quad . \quad . \quad (30)$$

where $\mu_0\kappa\mathbf{F}$ is the induced magnetisation.

In the common equation,

$$\mathbf{B}_i = \mathbf{F}_i + 4\pi\mathbf{I}_i \quad . \quad . \quad . \quad . \quad . \quad . \quad (31),$$

the intrinsic and induced magnetisations are lumped together for one thing, and it is assumed that $\mu_0 = 1$. The quantity κ is thus essentially a numeric, whilst μ is only a numeric by assumption. But whilst $\mu = \mu_i$, we have $\kappa = x^2\kappa_i$. Although magnetisation, whether intrinsic or induced, are of the same kind as induction, yet the reckoning is discrepant. Compare (27) with (25) for B and B_i. In (27) also, I may be either intrinsic or induced, so far as the ratio x goes.

The common equation, $\text{div.}\mathbf{D}_i = 4\pi\rho_i$, becomes

$$\text{div.}\mathbf{D} = \rho, \quad . \quad . \quad . \quad . \quad . \quad . \quad (32)$$

and the characteristic equation of Poisson becomes

$$\nabla^2 P = -\rho, \quad . \quad . \quad . \quad . \quad . \quad . \quad (33)$$

the 4π going out by the rationalisation. But P itself is given by

$$P = \Sigma\rho/4\pi rc. \quad . \quad . \quad . \quad . \quad . \quad (34)$$

The definition of current density,

$$\text{curl}\,\mathbf{H}_i = 4\pi\mathbf{C}_i,$$

becomes

$$\text{curl}\,\mathbf{H} = \mathbf{C}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (35)$$

Other changes readily follow. But now that I have explicitly stated the relation between my rational formulæ and the ordinary, I leave the irrationals—for good, I hope—and return to the rational and simplified formulæ, which are so much superior.

(To be continued.)

BOILERS.*

The principal types of modern steam boilers may be classified thus :—

Cornish boilers are horizontal cylindrical boilers with flat ends and one internal flue.

Lancashire boilers are similar to Cornish boilers, except that they have two internal flue or flues.

Multitubular boilers (marine type) are horizontal cylindrical boilers with internal flues, or fire tubes.

Multitubular boilers (loco. type) have a fire box at one end from which tubes run through to smoke box.

Water-tube boilers are constructed in various ways, the tubes, unlike multitubular boilers, contain the water, from which the steam is generally evaporated into a receiver at the top.

Vertical boilers are those in which the shell is placed in a vertical position. The internal arrangements of this class are very varied.

In addition to the above there are numerous designs combining two or more of the above in one boiler ; these are sometimes called compound boilers.

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Boiler Power.

Nominal Horse-Power—N.H.P.—This term is meaningless and misleading, as the horse-power obtainable by means of a given boiler varies enormously with the engine to which it supplies steam.

As, however, this term is still in use, we give the following definitions of it as proposed by different authorities :—

Watt's formula :—N.H.P. = cubic feet of water evaporated per hour.

Another rule says that for each N.H.P. a boiler requires

1 cubic foot of water per hour,
1 square yard of heating surface,
1 square foot of grate area,
1 cubic yard capacity.

The following formulæ are sometimes used :—

$$\text{Cornish boilers N.H.P.} = \frac{(D+d)\,L}{7}$$

$$\text{Lancashire boilers N.H.P.} = \frac{(D+2\,d)\,L}{8}$$

$$\text{Cylindrical boilers N.H.P.} = \sqrt{H+G};$$

where

D = diameter of shell in feet,
d = diameter of flue in feet,
L = length of shell in feet,
H = heating surface in square yards,
G = grate area in square yards.

The standard adopted for the horse-power at the Centennial Exhibition in the United States was 30lb. of water evaporated per hour at 70lb. pressure.

Inasmuch as the amount of steam per horse-power required by engines of different types as made at the present day varies from 12lb. per hour with the most economical triple expansion engines to 50lb. per hour with small single-cylinder engines, it is useless to specify the boiler by the horse-power required. Indeed, it is not exceptional for boilers to give four times the horse-power as found by the above rules.

Prof. Thurston estimates the water required per hour per horse-power in good engines where

I.H.P. = indicated horse-power,
w = lb. water per I.H.P. per hour,
p = steam pressure,

$$w = \frac{200}{\sqrt{p}};$$

while in the best engines

$$w = \frac{150}{\sqrt{p}}.$$

This gives, with good engines at 100lb. pressure, 20lb. water per I.H.P. per hour.

This gives with best engines at 100lb. pressure, 15lb.

This gives with best engines at 144lb. pressure, 12·5lb.

The best guide as to the evaporative power of boilers is the amount of *effective heating surface*. The quantity of water evaporated per square foot of heating surface varies with the type of boiler, and the conditions under which it is operated. Under ordinary conditions the following table will serve as a rough guide :—

Type of boiler.	Lbs. water evaporated per hour per sq. foot of heating surface.
Horizontal cylindrical	4 to 6
Multitubular	5 to 10*
Water-tube	3 to 5
Vertical	2 to 5

More efficient evaporative results can be obtained at the lower rates of evaporation, while for many other reasons it is advisable to have plenty of boiler power, so as to avoid forcing.

* Such high rates as 10lb. are only obtainable from boilers in locomotion, and this is attributed to the jarring or shaking, which hastens the liberation of the bubbles of steam as they form, together with the strong draught obtained with the exhaust from the engine, as is customary in locomotive practice.

It will be observed that a higher rate of evaporation is obtainable in the horizontal cylindrical boiler, which is attributable to the better circulation as compared with fire-tube or water-tube boilers.

Heating Surface.

The efficiency of the heating surface depends upon the difference of temperature at the inside and outside of the plate, as well as upon the thickness of the plate and nature of the surface. Rankine gives the following formula :—

If H = quantity of heat units transmitted per square foot per hour.
t = temperature of hot gases in flue.
t_1 = temperature of water in boiler.
K = a constant = 160 to 200 for steam boilers, then

$$H = \frac{(t-t_1)^2}{K} \text{ approximately;*}$$

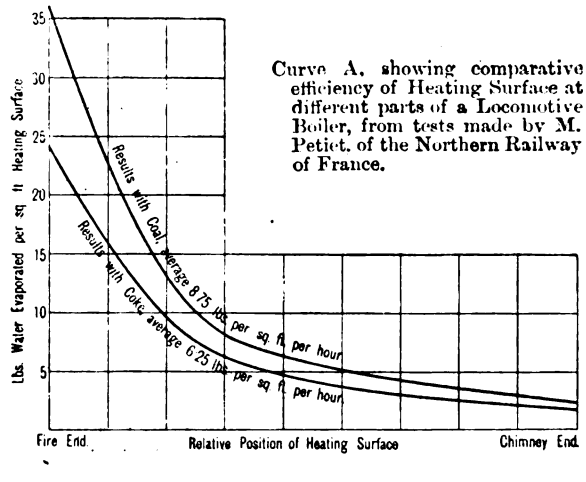
and, according to Peclet,

$$H = (t-t_1)\,A\{1+B(t-t_1)\},$$

where

A for polished metallic surfaces	=	·9
A „ dull „ „	=	1·58
B „ polished „ „	=	·005
B „ dull „ „	=	·0066

The curve A has been plotted from the results of actual experiments made by Havrez upon the evaporative power of



Curve A, showing comparative efficiency of Heating Surface at different parts of a Locomotive Boiler, from tests made by M. Petiet, of the Northern Railway of France.

different sections of a multitubular boiler of the locomotive type, and illustrates the rapid falling off in the efficiency of the heating surface as the distance from the fire increases. The length of the tubes was 12ft. 3in., and the boiler was divided as follows :—1st section, fire-box and 3in. of tubes; and four sections of tubes, each 3ft. long.

The results were as follows :—

Section of boiler.	Heating surface, in square feet.	Lbs. water evaporated per square foot heat surface, per hour in lbs.	
		Coke.	Briquettes.
Fire-box	76·5	24·5	36·9
1st tube section	179	8·72	11·44
2nd „	179	4·42	5·72
3rd „	179	2·52	3·52
4th „	179	1·68	2·31

It will be observed that the evaporation per square foot at the fire-box is fourteen times that at the last section of tubes for coke, and for briquettes sixteen times.

In practice it is probable that, owing to the formation of deposits, &c., a relatively larger duty will be done by the surface at the end of the flue. Sufficient heating surface should be provided for the best fuel and draught ever likely to be used; beyond that extra surface may be detrimental.

* It will be observed from this formula that H varies as the square of the difference of temperature.

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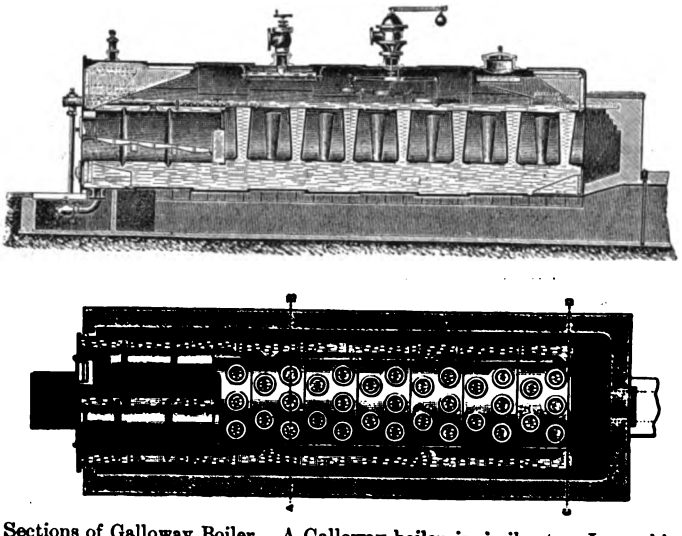
Relative Value of Heating Surface.

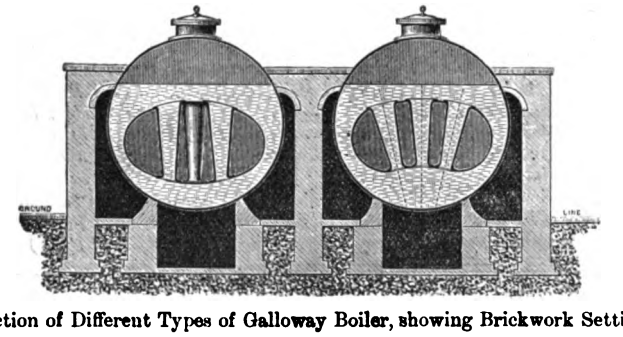
Horizontal surface above the flame = 1
Vertical " " " = ·5
Horizontal " below " = 0
Tubes and flues = $1\frac{1}{4}$ of their diameter.
Convex surfaces above the flame = $1\frac{1}{3}$ diameter.

Effective heating surface varies from $\frac{3}{4}$ to $\frac{5}{6}$ of the *total* heating surface, as the bottoms of internal flues and tubes are not so efficient as the tops and sides.

The effective heating surface of *multitubular boilers* is taken as the upper half of the furnace above the level of the grate bars, the surface of the combustion chamber above the level of the bridges, the actual surface of the back tube plates, together with the surface of the tubes measured externally, *i.e.*, external circumference × length between tube plates. The fire-box and chamber surface are generally stated separately from the tube surface.



Sections of Galloway Boiler. A Galloway boiler is similar to a Lancashire boiler, but with the addition of a number of conical water tubes into the flues.



Section of Different Types of Galloway Boiler, showing Brickwork Setting.

The Admiralty calculate the tube surface by the external circumference of tubes × length over tube plates, omitting the surface of both tube plates.

The front tube plates are always omitted.

In *locomotive boilers* the effective heating surface is given as the whole of the surface of the fire-box above the grate bars, less the aggregate area of the tubes, and the surface of the tubes measured externally and between the tube plates.

Generally speaking, for economy, the heating surface should not be less than one square foot, and not more than two square feet per 5,000 B thermal units to be transmitted per hour.

In torpedo boats one square foot of heat surface is often transmitting 12,000 to 15,000 B. T. units per hour, while in some mills as little as 1,000 B. T. units are absorbed per square foot per hour.

The natural action of water is that heated portions of water, as well as the steam when generated, seek a directly upward means of movement or escape. Colder portions seek the coolest means of descent where it is possible to have this, undisturbed by opposing currents.

THE VARIATION OF THE ELECTROMOTIVE FORCE OF BATTERIES WITH PRESSURE.*

BY HENRI GIBAULT.

By following up the ideas put forward by H. von Helmholtz in his theory on free energy we can deduce the following formula

$$q\frac{dE}{dp} = dv;$$

where E represents the electromotive force of a cell; q is the quantity of electricity developed when the reactions give rise to a variation of volume v, p representing pressure. This formula allows us to estimate the variation in the electromotive force of a battery due to pressure. Now, it is easy to measure this quantity, and thus verify the formula, and consequently the theory. This is what I did, and here give briefly the results.

When working with batteries which did not give off gas, I found that the variation of electromotive force was of the form

$$E_0 - E = ap - bp^2,$$

b being an infinitely small quantity, which only assumes importance at high pressures. Hence, for such batteries at moderate pressures, the variation of electromotive force with pressure is linear, which is in accordance with theory.

In an analogous investigation on batteries evolving gas, experiment showed that the variation of electromotive force could be expressed as a function of the pressure by the formula

$$E_0 - E = A\lambda p + cp,$$

c being again very small, which is equivalent to saying that for moderate pressures the variation of electromotive force follows a Napierian logarithm, as is also shown by the first formula.

The agreement between theory and experiment goes further still, and becomes striking by reason of the similarity exhibited between the numbers indicated by one and by the other, as one can satisfy oneself by the few examples set out in the table below, which shows the variations of the electromotive force of different batteries, expressed in ten-thousandths of a volt, due to a variation of pressure of 100 atmospheres.

Battery.	Calculated variation.	Observed variation.
Daniell (20 % $ZnSO_4$)	+ 5·17	+ 5
" (27·56 % $ZnSO_4$)	+ 2·20	+ 2
Warren de la Rue (1 % ZnCl)	+ 6·62	+ 7
" " (40 % ZnCl)	− 5·04	− 5
Planté Accumulator (8·8 % H_2SO_4).	− 12·70	− 12
Volta	− 586·00	− 600
Bunsen	− 383·00	− 405
Gas battery	+ 865·00	+ 845

I think, therefore, I may conclude that there exists for moderate pressures perfect agreement between the numbers deduced from H. von Helmholtz's theory and those obtained experimentally. In the case of excessively high pressures, variations due to the secondary effects, inevitable under such conditions, are probably added to the normal variations.

* *Comptes Rendus*, Tome CXIII., No. 15.

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SATURDAY, October 31st.

OLD STUDENTS' ASSOCIATION.

7 p.m. Annual Dinner at the Holborn Restaurant.

MONDAY, November 2nd.

ROYAL INSTITUTION.

5 p.m. General Monthly Meeting.

SOCIETY OF ENGINEERS.

7·30 p.m. Paper to be read on "Corrosion in Steam Boilers." By J. H. Paul, B.Sc.

FRIDAY, November 6th.

PHYSICAL SOCIETY.

5 p.m. Paper to be read on "Corresponding Temperatures, Pressures, and Volumes." By Prof. Sydney Young.

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The Electrician.

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THE USE OF SMALL MOTORS.

With a keen sense of disappointment many electrical engineers recognise the fact, which many others ignore with complete indifference, that there is no demand for, and at present but little likelihood of, the extended use of small electric motors for industrial purposes in this country. A number of electrically driven pumps, fans, cranes, and mining machines are in use; but we do not allude to these, or to electric tramways and launches, so much as to the numerous uses to which we have so often been told that motors may be applied. It is still somewhat doubtful whether an appreciable demand for current for motive power would be a boon to or a strain on the resources of supply companies. A better load throughout the day would, of course, be a great advantage, but during the winter months there would be a two-fold demand during the latter part of the afternoon. If this should be large enough to require increased generating plant, it would not only mean that no smaller proportion would stand idle during the winter's day than at present, but a considerably larger propor-

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tion would so stand in summer. It is not for want of careful consideration of the problem that this state of things is still to be found. The question has received the close attention of several men who could do an excellent business in the sale and erection of motors; and several central station managers, who could deal with a larger load than they have at present, have tried to encourage business in this direction. We know quite enough about transmission of power; there is not a problem, from a dentist's drill to the driving of the largest factory in the country, that could not be taken in hand at once by half-a-dozen manufacturing firms.

The price of labour is so low that for occasional work, hand power which demands no outlay of capital is to be had everywhere, and carpenters and jobbing ironmongers will employ a dozen hands and prefer to utilise manual labour for sawing, drilling and turning, rather than invest in a gas engine or a steam engine. For continuous work the question resolves itself at once into the price. We do not know, and do not expect to know for a few years, the price at which electrical energy can be supplied. The smaller stations in London can hardly hope to go below 5d. per unit and pay a 10 per cent. dividend at that. It is quite possible that when a demand for a million lights is made on the Deptford station, they will be able to supply at 8½d.; and by that time—we do not mean to be ironical—a small alternate-current single-phase motor will probably have been found. But even putting the price of a unit at 5d. and the efficiency of a motor at 85 per cent., the horse-power hour would come to 4·4d. as against about 1d. an hour with a gas engine. The important question to be considered is in what trades or for what purposes can small motors be profitably used. It seems very improbable that any motors running nine hours a day and yielding more than four horse-power can be used, unless under very exceptional circumstances. At 5d. per unit this would cost 18s. a day.

Although the price of a thing is that which it will fetch, the consideration of convenience cannot be estimated in pounds, shillings and pence, because different people will attach different values to it. The convenience of a motor, and, more than this, the convenience of separate motors for driving separate machines, is very great; and it remains to be seen how much the public will care to pay for it. Another convenience is the ease with which a motor can be started and this is of great value in intermittent work. All this is fully recognised by those who have been trying to develope the sale of motors; and the important matter is now to discover situations where these conveniences will make it worth while to use them. Hydraulic supply threatened at one time to be a formidable rival, but the purposes for which it has been used are very few compared with those for which a motor is suitable.

We have said that while some engineers have given much thought to this lack of demand for small motors, others ignore it. A rather striking example of the latter attitude is to be found in the prospectus of the National Electric Supply Company, which has been formed for supplying Preston with electric light and motive power. Electric supply companies have generally kept this question of motive power rather in reserve; but in the prospectus before us it is brought into considerable prominence. A good deal is made of a statement volunteered by Mr. Edison "during his recent visit to London." "The next thing you have to do will be to turn your electric force into motive power. Ah! America's the place for that!" We can understand that confusion between force and power is as common in America as with us; but to turn force into power only means that it must be given room to work. That is just what we want. Our dynamo builders do not need to be told how to build motors, they want to know who requires them. This prospectus contains two paragraphs on this subject, and commences with the truism, "The application of electricity as motive power in this country is yet in its infancy." Of course the prospectus tells us about America, and we are always glad to receive any scientific information from that country, and to pick up practical hints; but when we come to commercial matters and prices we may be thankful that our conditions of life are so widely different that no useful comparison can be drawn. The shrewd people of Lancashire are quite familiar with the renting of power; and they know a thing or two about what Americans can do and what they cannot do, what they try to do and how much it costs them. "The countless purposes to which electricity may be usefully applied as a motive power, especially for driving light and small machinery, only require to be understood to assure a large and general demand for current, especially during the day-time. The Company propose to supply motors at a small rental." How very dull must we be as a nation, in the eyes of the author of this prospectus, that we have not "understood" a few of these "countless purposes;" and it is only fair, if we criticise him, to give the detailed suggestions in full. "Amongst the many trades which could use the current may be mentioned:—Jewellers, for driving lathes; hairdressers, for hair-brushing machinery; cutlers, for grinding and polishing; grocers, for coffee mills; driving fans, for ventilation; tobacconists, for tobacco-cutting machines; turners, in wood or metal work; printers, for printing machines; gas fitters, &c., for drilling; and numerous trades where sewing machines are used." Little motors taking one or two hundred watts might be useful for small lathes for work which cannot be done well by a foot-lathe; but it must be remembered that the employer can only be expected to use them if he can get more or better work to cover the expense. Hair-brushing has already been tried, and is one of those irregular operations for which a motor is very well adapted. We are doubtful about cutlers, grocers, and some of the other trades. When power is wanted by them it is wanted in long spells, and it is worth starting an engine. If the business is not large enough to stand this, it will find a difficulty in paying for electrical energy. If printing could be done with any economy or advantage by electricity we should welcome it; but no one has yet shown where the economy comes in. We should like to see a motor on every sewing machine; and it is possible that, where large numbers are used in one building, power might be transmitted to them electrically more economically than by belts. Small lifts for occasional use could be worked more cheaply by current than by hydraulic power, and we believe an endeavour is being made to push them; there are several at work in London.

The prospectus alluded to gives a list of the number of lamps connected to the mains of the London supply companies, but maintains a discreet silence about the number of motors used. It fails to explain who is to pay the rent for the motors. If a shop were opened in, say, Queen Victoria-street, for the free presentation of motors to anyone who would undertake to make regular use of them in their business we doubt if the demand would be so very great. It is, however, a mistake to suppose that all this is an evil. True, it is not good for electrical trade, but it proves that we can work more cheaply by other means, and that the productive power of this country is therefore greater than if such expensive labour-saving assistance were needed. Encourage by all means the use of small motors, but let us not deceive ourselves or the confiding public.

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REVIEWS.

The Practical Telephone Handbook. By JOSEPH POOLE. (London: Whittaker and Co. 1891.)

This essentially practical book is published at an opportune moment, owing to the recent expiration of the Bell and Edison patents that have so long checked the development of the telephone in England. We have already seen a very considerable increase in telephonic activity throughout the country, and there is no doubt a demand for books giving reliable information on the subject.

One cannot help noticing that in Mr. Poole's book a considerable number of the illustrations are old friends, that have already done duty in Mr. Preece's book on the Telephone and in other similar works; and when, as in the case of the illustrations of the Mix and Genest and Berliner transmitters, this is coupled with the fact that the figures do not show the latest form of instrument, at all events as known in this country, it is impossible not to regret that new blocks were not prepared. On the whole, however, Mr. Poole may be congratulated on the discretion that he has shown in his choice of apparatus for description; for, on the one hand, he has kept within reasonable limits the pages devoted to instruments of purely historical or experimental interest, while, on the other hand, his book contains readable accounts of all the best known and most widely used instruments, together with a considerable amount of fresh information not hitherto published in book form.

Commencing with a clearly-written preliminary chapter, dealing with such elementary electrical knowledge as is required for the apprehension of the principles involved in telephony, Mr. Poole proceeds, in a second chapter, to describe such batteries as are commonly employed in telephonic work; next he gives a concise account of the history of the telephone, and goes on in Chapters IV. and V. to describe the receivers and transmitters in common use at the present time. Signalling apparatus and intermediate switches and switchboards are dealt with in the next two chapters, the various details of these and their connections being very clearly illustrated by a number of well-chosen diagrams. Chapter VIII. is devoted to switchboards of the multiple type, and IX. to special exchange systems, such as that used by the British Post Office and those of the National and Mutual Companies at Manchester, together with the system in use at Paris. The descriptions of these several systems are somewhat brief, and one regrets in particular that the novel and interesting arrangements adopted by the Mutual Company at Manchester are not more fully illustrated. There is, however, more information than would perhaps be suspected, considering the small compass.

Test-room appliances, out-door construction, long-distances working, faults and their localisation, underground work, and miscellaneous telephone apparatus and applications, comprise the subject matter of the remaining chapters of the book; and are valuable, giving, as they do, much reliable information of a practical kind rarely to be found in text books. An appendix, describing the new "Collier" and "Mercadier" receivers, and containing an abstract of Mr. Bennett's Paper on "The Telephoning of Great Cities," completes the book. Considering its moderate dimensions, the book is very comprehensive, and, taking it altogether, it may be safely recommended to all who take an interest in practical telephony.

Le Gaz et ses Applications. Par E. DE MONT-SERRAT et E. BRISAC. Bibliothéque des Connaissances utiles. (Paris: J. B. Baillière et Fils.)

This is a small, well-illustrated, and interesting book, treating in a very practical way of the uses and applications of gas. A good elementary account of the manufacture and "canalisation" is given; but all this information can be found elsewhere. The interesting chapters are those which describe numerous kinds of gas burners, and which criticise their performances. These are well worth the attention of electrical engineers, who ought to be fully alive to the great perfection to which gas engineering has been carried. Some very interesting pages are devoted to the subject of illumination, and the geometrical laws which govern it are briefly alluded to. We have found much useful information on units of light and photometry, and will only criticise one of the few statements in which electric light is alluded to. Quoting Brown-Séquard, who has found that the contraction of the pupil of the eye is produced mainly by yellow light, and the experiments of M. A. Charpentier, who has found that the eye is very much more sensitive to feeble rays from the red end of the spectrum than from the blue end, the authors argue that when other illuminants, including glow lamps, are replaced by arc lamps, three or four times as much light is required "if one wishes to obtain analogous effects from the point of view of vision." They adduce as a proof that the yellow rays of the sun are the most intense. Now, while the light of the arc is rich in blue and actinic rays, it is on the whole much more yellow than the sun. It is of a pale primrose colour. No information is given as to how M. Charpentier measured the "quantity of light:" if it was done with a photometer it must have produced a certain amount of illumination. Was this measured against the corresponding amount of illumination of a certain colour that could be got out of the standard source of light used in the photometer? Or was the same "tone" reproduced in different hues? The figures given are 7·4 for extreme red, 17·76 yellow, 362·6 middle green, 1150·25 *bleu franc*, in arbitrary units apparently, and each of these is just sufficient to allow the eye, after 20 minutes' complete rest, "to discern the forms of external objects." The point is of more than merely physiological interest; but if a certain amount of light is produced, how can it be usefully measured except by the eye, and if the eye can see it what more is required? It is easy to understand that one kind of sugar is three times as sweet as another, meaning that one third of the weight will produce the same sweetness; but two measurement are there compared, and here we only have one.

The Gas, Water and Electric Lighting Companies' Directory. Edited by CHARLES W. HASTINGS. (London: Hazell, Watson and Viney.)

This is a handy and clearly printed little Directory of some 200 pages. It is to be regretted, however, that the very item of information so frequently wanted, namely, the price of gas, is omitted here, although contained in the volume on Gas Statistics by the same author. If space is limited perhaps the columns headed "Distance from London" and "Railway" might be abolished to make room for this much-needed heading. The Electric Lighting section is fairly accurate, complete, and up to date.

THE DETERMINATION OF CURRENTS IN ABSOLUTE ELECTRO-MAGNETIC MEASURE.

BY G. F. C. SEARLE, M.A.

(*Continued from page 691.*)

§ 25. **Calculation of some Simple Cases.**—In order that we may begin to see some fruits of our labours we will find the magnetic force produced by a long straight wire and by a long uniform solenoid at points inside it.

Long Straight Wire.—This must, of course, form part of a closed circuit; but we may suppose that the rest of the circuit is so distant that for points near the wire the distribution of magnetic force is symmetrical with respect to the wire. In a plane perpendicular to the wire describe a circle of radius r, having the centre of the wire for its centre (Fig. 24). The magnetic force F will be the same all the way round this circle, and its direction will be everywhere along the circle. In moving the pole completely round the circle in the direction indicated by the arrow an amount of work $-4\pi i$ will be done by external agencies (*see* § 24). The negative sign indicates that the magnetic force due to the current is in the direction of the arrow. The work done by the magnetic force is $2\pi r \times F$. Equating these two expressions for the work done, we have $2\pi r F = 4\pi i$. Hence $F = 2i/r$, or the magnetic force at any point is inversely proportional to the distance of the point from the axis of the wire. The method of proof shows us that the result is equally true if the conductor is a hollow cylinder, whose

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section is two concentric circles. If the return current flows back by a tube outside the wire, and concentric with it, then, since the total current through any curve drawn so as to embrace the outer cylinder is zero, it follows that the magnetic force everywhere outside the outer cylinder is zero. At all points between the inner and outer cylinder it has the value $2\,i/r$.

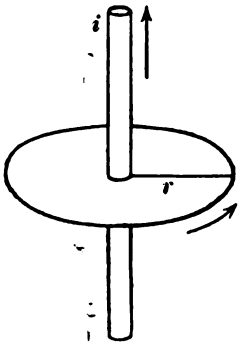

Fig. 24.

Long Uniform Solenoid.—Take a long solenoid (Fig. 25), uniformly round, so that there are n turns of wire per centimetre of its length. Consider a rectangle, A B C D, the side B C being inside the solenoid, parallel to the axis, and one centimetre long. Let the side A D be outside the solenoid. Then, if the solenoid is long, and B C is not near either end, the magnetic force F along B C will be very nearly uniform, and there will be no appreciable magnetic force along A D, A B, or C D. Take a unit magnetic pole round the path A B C D. Its path is linked n times with the current, so that

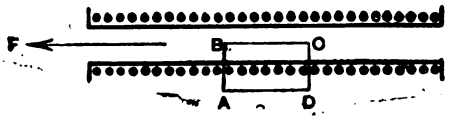

Fig. 25.

the work done is $4\pi n i$ (*see* § 24). But the only part of the path in which any work is done is the part B C. The work done here is F, since B C = 1cm. Hence, equating the two expressions for the work, we have $F = 4\pi n i$, a well-known expression.

§ 26. **Case of a Circular Current.**—The magnetic potential at any point, P, due to a current of strength i is $i\,\Omega$, where Ω is the solid angle subtended by the circuit at P. The magnetic force in any direction, S, is $-i\,d\Omega/d\,S$ in the direction in which S increases. We will now apply this to a circular current. Let A (Fig. 26) = radius of current, x the distance of a point P on the axis from the centre O of the coil.

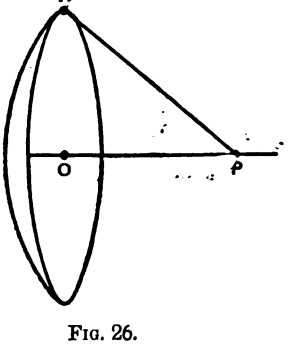

Fig. 26.

We shall have to make use of the following very important result in three-dimensional mensuration. Take a sphere and describe about it a cylinder touching the sphere round the equator (Fig. 27). Draw any two planes A A′ B B′ parallel to the equatorial plane. These will cut off from the cylinder a ring and from the sphere a certain portion of the surface contained between the two proper lines of latitude. Then it can be easily proved that the areas cut off by the two planes from the sphere and the cylinder are equal. Thus if h be the distance apart of the two planes, and r the radius of the sphere, the area of the ring on the sphere is $2\,\pi\,r\,h$. The solid angle subtended at O by the ring is, of course, $2\,\pi\,r\,h/r^2 = 2\,\pi\,h/r$ (*see* § 8). Returning now to the case in hand, we have to calculate the solid

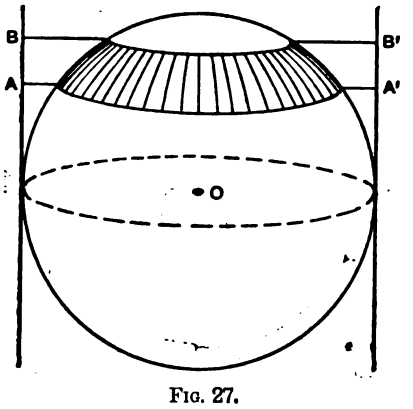

Fig. 27.

angle subtended by the circle at P. About P describe a sphere of radius A P. The plane of the circuit will cut off from the sphere a spherical cap, whose height is A P − O P. Its area is, therefore, $2\,\pi\,A\,P\,(A\,P - O\,P)$, and the solid angle subtended by it at P is

$$\Omega = 2\,\pi\,\frac{A\,P - O\,P}{A\,P},$$

or

$$\Omega = 2\,\pi\left(1 - \frac{x}{\sqrt{x^2 + a^2}}\right).$$

Thus,

$$V = 2\,\pi\,i\left(1 - \frac{x}{\sqrt{x^2 + a^2}}\right).$$

Hence, F = magnetic force in the direction in which x increases

$$= -\,d\,V/d\,x = 2\,\pi\,i\,\frac{a^2}{(x^2 + a^2)^{\frac{3}{2}}}.$$

When $x = 0$, *i.e.*, at the centre of the coil, $F = 2\,\pi\,i/a$.

§ 27. **Tangent Galvanometer.**—A circular coil of radius a is placed with its plane in the magnetic meridian, and a small magnet is hung at the centre. Let H (Fig. 28) be the earth's horizontal magnetic force, F the magnetic force at the centre of the coil due to a current i. H and F are then at right angles, and their resultant makes an angle θ with the magnetic meridian given by $\tan\theta = F/H$. The magnet places itself along the direction of the resultant magnetic field, and indicates a deflection θ. Thus, $2\,\pi\,i/a = H\tan\theta$, or $i = H\,a\tan\theta/2\,\pi$.

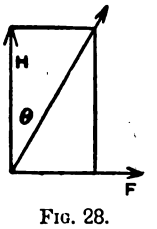

Fig. 28.

If there are n turns of wire close together, and a is the mean radius, we shall have $2\,\pi\,n\,i/a = H\tan\theta$.

or,

$$i = \frac{H\,a\tan\theta}{2\,\pi\,n}.$$

Thus the tangent galvanometer gives us a means of measuring currents when we know the following data. a the mean radius of the coil, H the strength of the earth's horizontal field, and θ the angle of deflection. In order that a may be capable of accurate determination the radius of the coil should be considerable, and if it has more than one turn of wire the turns should be very close together. Since at points not exactly at the centre of the coil the magnetic force is not exactly that

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given by $F = \frac{2\pi n i}{a}$, the magnet should be as short as possible in order that its ends may be at places where the magnetic force is as nearly as possible equal to its value at the centre. We can easily find the variations of the magnetic force at points on the axis very near the centre, by expanding the complete value of F in ascending powers of x/a.

$$\text{Thus, } F = \frac{2\pi i a^2}{a^3\left(1+\frac{x^2}{a^2}\right)^{\frac{3}{2}}} = \frac{2\pi i}{a}\left(1 - \frac{3}{2}\frac{x^2}{a^2} + \frac{3\cdot 5}{1\cdot 2}\cdot\frac{x^4}{2^2 a^4} + \dots\right)$$

Thus, if $a = 30$ cm. and $x = 1$ cm., the value of F differs from that at the centre by less than one part in 600. To determine the variation in the magnetic force at points in the plane of the coil, very close to the centre, is a rather more difficult matter, and one which we shall not discuss at present.

§ 28. **Galvanometer Constant.**—The value of the magnetic force at the centre of a coil when unit current is flowing through it, is called the galvanometer constant of the coil. As a rule a coil has more than one turn of wire, and the windings occupy a finite space. We shall proceed to calculate the galvanometer constant for a coil whose mean radius is a, the radial depth of the windings being $2h$, and the axial length $2k$ (see Fig. 29). We may, to a very high degree of approximation, replace the current flowing in the n turns by a uniform distribution of current ρ per square cm. of the section. If the value of the current is i we have $ni = 4hk\rho$. Consider a small part of the section at the point whose co-ordinates,

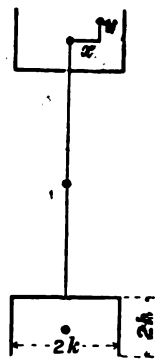

Fig. 29.

referred to the centre of the section, are x, y. If $dx\,dy$ be the small area, the current through it is $\rho\,dx\,dy$. The magnetic force at the centre of the coil due to this small part is by § 27

$$= \frac{2\pi\rho\,dx\,dy}{a+y}\left(1 - \frac{3}{2}\frac{x^2}{(a+y)^2}\right)$$

$$= \frac{2\pi\rho\,dx\,dy}{a}\left(1 - \frac{y}{a} + \frac{y^2}{a^2}\right)\left(1 - \frac{3x^2}{2a^2}\right)$$

$$= \frac{2\pi\rho\,dx\,dy}{a}\left(1 - \frac{y}{a} + \frac{y^2}{a^2} - \frac{3x^2}{2a^2}\right)$$

where we have expanded the quantity $a+y$ in the denominator and neglected powers and products of x/a or y/a higher than the second. To find the whole magnetic force at the centre, we must integrate this over the section of the coil.

Thus for G, the galvanometer constant, we have

$$G\,i = \frac{2\pi\rho}{a}\int_{-h}^{+h}\int_{-k}^{+k}\left(1 - \frac{y}{a} + \frac{y^2}{a^2} - \frac{3x^2}{2a^2}\right)dx\,dy$$

$$= \frac{2\pi\rho}{a}\left\{4hk + \frac{4h^3k}{3a^2} - \frac{4hk^3}{2a^2}\right\} = \frac{2\pi ni}{a}\left\{1 + \tfrac{1}{3}\frac{h^2}{a^2} - \tfrac{1}{2}\frac{k^2}{a^2}\right\}$$

the term $-y/a$ vanishing on integration;

$$\text{therefore } G = \frac{2\pi n}{a}\left\{1 + \tfrac{1}{3}\frac{h^2}{a^2} - \tfrac{1}{2}\frac{k^2}{a^2}\right\}.$$

If, as is generally the case, h and k are quite small compared with a, an approximate knowledge of h and k is sufficient. The quantity which we require to know accurately is a.

(To be continued.)

THE FRANKFORT EXHIBITION.—XV.

(FROM OUR SPECIAL CORRESPONDENT.)

The Kohlrausch ammeter, as made by Hartmann and Braun, is now tolerably well known to English engineers; and this firm has lately made an instrument of this type for the Lahmeyer Company, of Frankfort, in which the spiral spring is replaced by mercury. Fig. 1 shows the external appearance of the instrument. A thin tube of soft iron with an insulating covering floats in a cylindrical vessel filled to a certain height with mercury. The vessel is of non-magnetic material, and is of small cross section; round it is wound the solenoid. The top of the core carries two projections to keep it from the sides of the containing vessel. When the current is put on, the solenoid is sucked down into the mercury until equilibrium is established. The total distance travelled, about four inches, is graduated in millimetres on the left side of the scale and in amperes on the right, and the scale can, of course, be spread out at any desired position by giving the iron core a corresponding particular shape. The instrument must, of course, be always kept in a vertical position, which is, perhaps, a disadvantage, and the rise and fall of the surface of the mercury with the temperature would also introduce errors.

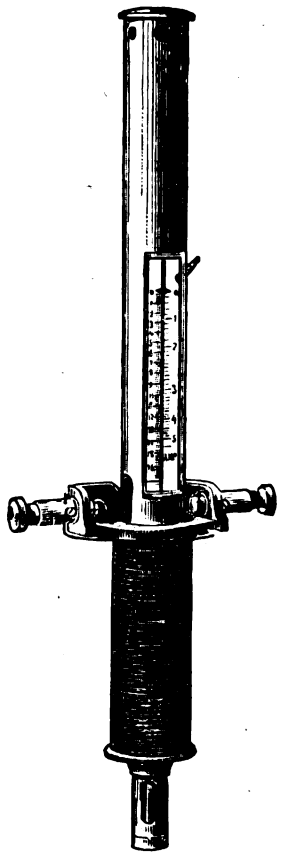

Fig. 1.—Kohlrausch Mercury Ammeter.

In Fig. 2 is illustrated a differential voltmeter made by Hartmann and Braun. Two solenoids act on one core, which dips into each, and is hung on a long spiral steel spring. The movements of this core are transferred to a lever carrying the index, and also two contact arms, which actuate relays ringing different toned bells. The smallest difference in the pressure at the terminals of the coils pulls the core up or down, and brings one of the contact arms up towards its contact piece. The contacts are set so that they are made when the difference of pressure is the maximum allowed. One solenoid is usually kept at the standard pressure, and the other is connected to the circuit where it is desired to maintain the same standard pressure. The voltmeter is useful for running dynamos or batteries in parallel or in the three-wire system. Perhaps one of its most useful applications is in measuring the loss of volts in electric light feeders, one solenoid being connected directly with the dynamo, and the other with the far end of the feeder.

The recording voltmeter (Fig. 3) consists of a Kohlrausch dead-beat spring galvanometer, the index of which carries a pen pressing against a sheet of paper wound on a revolving drum. The pressure of the pen against the drum can be regulated by means of a micrometer screw at the top of the spring. The drum is worked by clockwork, and revolves once in 24 hours. To avoid the necessity of printing different sheets for every instrument the volts are read off by means of a glass scale, the scale being placed over the unrolled sheet of paper after the record has been made. The coil shown on the left is the additional resistance required, and is, of course, wound non-inductively. A similar instrument is also made as a recording ammeter.

Fig. 4 illustrates the motor wattmeter made by the same firm, of which a short notice was given in an early article. The main current enters at the terminal K_1, and traversing the mercury trough R_1, passes on to the copper disc S radially, then

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out again by the trough r, and thence to the terminal K_2. The electro-magnet E has its exciting coil arranged as a shunt to the main circuit. The retardation is due to the

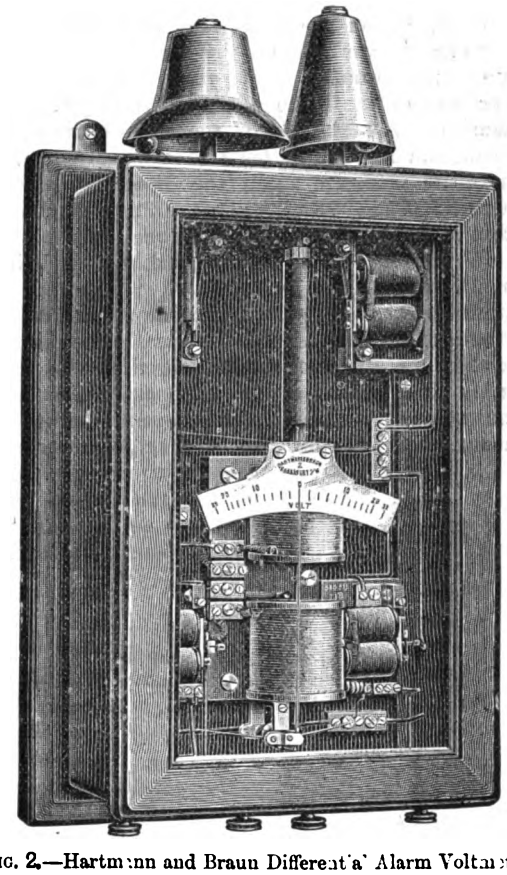

FIG. 2.—Hartmann and Braun Differential Alarm Voltameter.

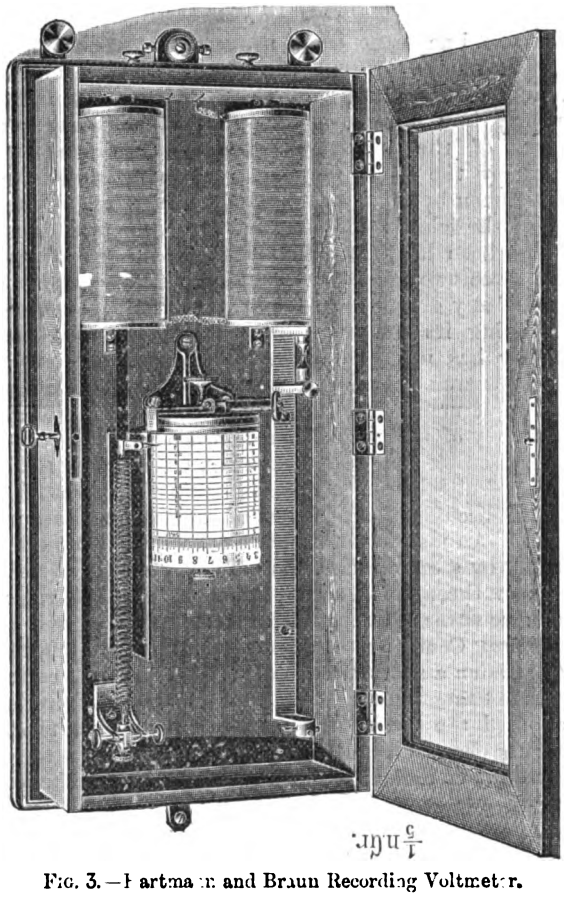

FIG. 3.—Hartmann and Braun Recording Voltmeter.

Foucault currents generated in the rotating disc. The disc works a train of clock-wheels, Z, which actuate recording dials. The meters are made to take currents from 50 amperes up to 1,000 amperes, and are arranged also for use on three wire circuits.

Amongst the apparatus shown by Hartmann and Braun for

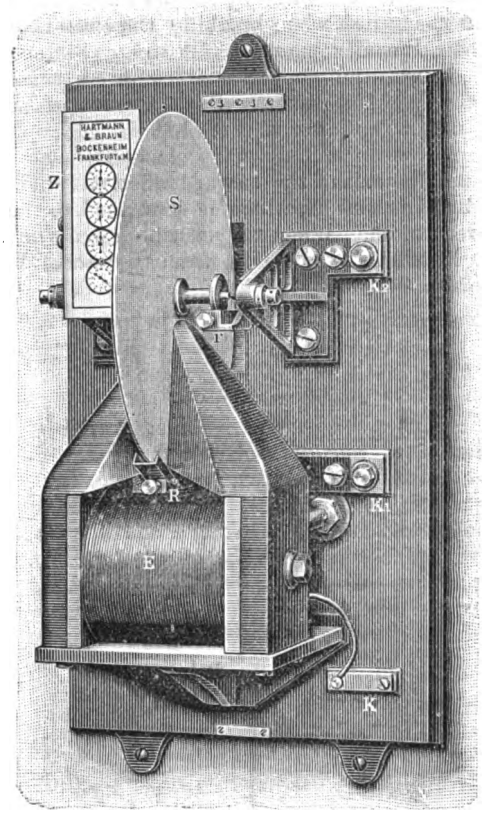

FIG. 4.—Hartmann and Braun Motor Meter.

use with accumulators are several ingenious instruments. One, for instance, is a current index for showing the direction of the current. This consists simply of a magnet, under which runs the wire carrying the current, the magnet turning to the right or left according as the current is coming from or going to the battery. These little instruments were very much used throughout the Exhibition. One of this firm's automatic cut-outs is shown in Fig. 5. The cut-out consists of a copper strip mounted on a vulcanite disc, which is acted on by the spring G. The projecting knob n of the armature of the electro-magnet fits, when the circuit is not broken, into a recess bored in the vulcanite disc, into which is also fitted

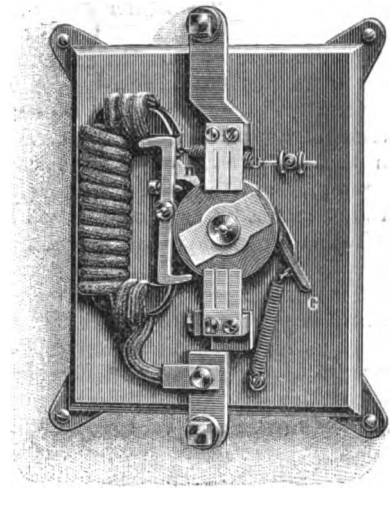

FIG. 5.—Hartmann and Braun Automatic Cut-out.

a small roller to prevent friction between the knob and the vulcanite, and thus allow the knob to slide easily and smoothly. According as the instrument is arranged, when the current

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increases or decreases by a fixed percentage, the armature is drawn round into the position shown in the illustration, and the knob *n* is drawn out of the hole in the vulcanite, the cut-out being pulled sharply round by the spiral spring G.

The following device used by Siemens and Halske to avoid sparking at the switch when breaking the circuits of the coils exciting their dynamos may present some points of interest. From the substantial copper contact pieces of an ordinary pull over switch S (*see* diagram, Fig. 6), wires are run to two carbon rods, C. The lower of these rods is fixed, but the upper one can be moved up and down by a copper band B, which is wound round the axis of the toothed wheel W. The wheel W is rotated by the screw H, which is connected to the handle of the pull-over switch. When the exciting circuit is made, the screw H is lifted and disengaged from the wheel W, and the

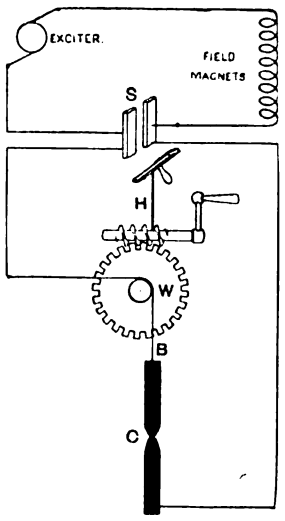


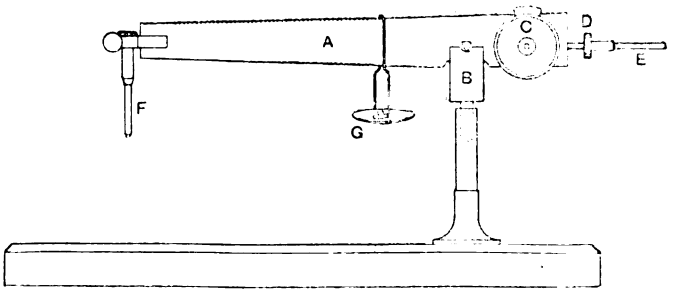
FIG. 6.

carbons fall into contact. When the switch handle is pulled down, the screw H is lowered on to the wheel W, and the exciting circuit is then finally broken by winding the carbons apart.

THE RELATIVE HARDNESS OF VARIOUS KINDS OF ELECTRO-PLATING.

Few exact experiments have been recorded dealing with the subject to which we now propose to devote a little consideration. The reason for this apparent neglect of what is a matter of some scientific interest, as well as of much technical importance, is to be found in the fact that the accurate determination of the hardness of metals and alloys has only been possible comparatively recently. The fundamental error made by all the earlier devisers of apparatus for the determination of hardness, has been that they have overlooked the fact that the hardness of a material is distinct from its tenacity, and methods of measuring the one must be so planned as to be uninfluenced by the other. The failure to appreciate and comply with this condition has been the cause of much wasted ingenuity and effort, as anyone will admit who cares to refer to the published accounts of former investigations made in this direction.

A few years ago an instrument was designed by Mr. Thomas Turner, of Birmingham, which avoided the errors of its forerunners almost completely. Like all notable improvements it owed its excellence to the fact that regard had been paid by its inventor to first principles. Having studied the various methods that had been from time to time proposed, and in some cases actually used in default of anything better, he perceived their inherent defects, and considering precisely what it was that was required to be measured, he abandoned the lines upon which the largest measure of success had been previously attained, and struck out in an entirely new direction. The instrument which was the outcome of his researches is simple enough, as may be seen from the illustration, in which one form of it is shown. A graduated beam A, with unequal arms like a steelyard, rests upon knife-edges which bear upon suitable steel or agate surfaces carried on the head of the pillar B. A counterweight, C, on the short side of the beam serves to balance the longer arm, and final adjustment of equilibrium is made by the nut D moving along the screw E. At the end of the longer arm of the beam is a brass style, F, shod with a small diamond. A scale pan, G, moves along the longer arm of the beam, and by its position and the weights it contains, determines the pressure which the diamond point exercises upon any surface placed beneath it. The pillar, B, has the upper part bearing the beam pivoted vertically to the lower, so that the beam can be swung bodily round in a horizontal plane, thus moving the diamond point in an arc of any desired length. It will be at once apparent that, when a highly-polished surface is placed beneath the diamond point and a load of suitable magnitude caused to rest upon it by sliding the scalepan along the beam, on drawing the point across the surface by swinging the beam upon its pivot, an abrasion will be made on the surface if the pressure be sufficient. The load that is necessary to produce this effect is a measure of the hardness of the material under examination. When this instrument is first used by one unfamiliar with the indications it gives, a difficulty is experienced in discriminating



between the line made by a pressure on the diamond point, which is insufficient to cut through the surface of the test-piece, and a true abrasion. Even with a very light load, particularly in the case of somewhat soft materials, a sort of smoothing of the portion of the surface which has been traversed by the diamond point will be perceptible, and is easily mistaken by the inexpert for a true scratch. When once the use of the sclerometer—for that is the name of the instrument—has been learnt, no difficulty is found in distinguishing between these two appearances, and the determination of the hardness of any given substance becomes comparatively easy.

Considering its merits it is a little surprising that the sclerometer has not been more widely used for purposes of technical research. A question, such as the relative hardness of the film of metal deposited by electrolysis as a protection to the base body of the article coated, which is acknowledged to be of considerable importance, and has hitherto been subjected to no more fruitful form of investigation than that of vague qualitative discussion, can be settled with ease and accuracy by its means. An instance of what can be done in this direction is afforded by a determination that was recently made of the hardness of three well-known plating materials, silver, nickel, and the zinc-silver alloy now being introduced by the London Metallurgical Company, a description of which appeared in *The Electrician* a short time ago. The tests were carried out by Messrs. Stanger and Blount, of Broadway, Westminster, who adopted the use of the sclerometer in their practice as engineering chemists shortly after its appearance.

The results of their investigations are shown in the following table :—

Sample.	Condition of sample.	Hardness.
Nickel anode	Rolled	11·5
Nickel anode	Rolled, annealed	8·5
Areas anode	Cast	5·5
Silver anode	Rolled	4·5
Silver anode	Rolled, annealed	3·5

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The numbers represent the weight in grammes to which the pressure of the diamond point upon the test-piece is equivalent. An idea of their value may be obtained from the numbers corresponding to the hardness of a few common metals. Thus, ordinary commercial lead requires a pressure of one gramme on the diamond point to be definitely scratched; tin has a hardness of 2·5; copper about 8; mild steel averages 21; while harder steels and hard cast irons have a hardness of 25·30 or more; and ordinary window glass gives a result of about 60.

The figures are interesting as establishing the claim made for "Arcas" that it is appreciably harder than silver. Of course, both are considerably softer than nickel, the hardness of which is well known, and for many purposes objectionable. The value of the testimony in favour of the new method of plating would be much enhanced by the publication of the results of experiments made on the metals in their deposited form, as it is quite conceivable that an alteration in their molecular condition might occur in the act of deposition, and their hardness, among other properties, might suffer change.

THE NEW YORK RAPID TRANSIT COMMISSION.

For some time past the proceedings of the New York Rapid Transit Commission have been viewed with increasing suspicion by American electrical engineers; and the latest report issued by the Commission, recommending the adoption of a modified "Reno" tunnel, has been met with general disapproval. The complete ignoring of the Greathead system of tunnelling appears to have occasioned surprise, but from all accounts underground New York is not altogether suitable for it. Insinuations of politico-municipal jobbery are, as usual, being freely made; it is hinted that a tunnel burrowing far below pipes and foundations, and disturbing no vested interests, could not for that very reason commend itself to local politicians. Our New York contemporary, the *Electrical Engineer*, calmly gives it as its opinion that a great economy would be effected if the municipal opponents of the deep-tunnel scheme were traced, their worth ascertained, and the sum added to the cost of the tunnel.

The "Reno" tunnel, a description of which appeared in the *Electrical World* of February 14, 1891, comprises two double tracks, one above the other, and the proposed method of construction is somewhat as follows:—One side wall would be constructed at a time, and for this purpose a trench 38ft. deep and 3ft. wide, and lined with planking, would be dug. This trench would be filled in with concrete up to about 11ft. of the surface, and the road relaid. After the other wall has been built up in the same manner, the intervening soil would be excavated, without, so it is asserted, disturbing the street above, by a steel cutting edge, behind which a channel steel roof would be built in by sections. It is proposed to coat the steel roof with asphalte, and to harden the soil in the immediate vicinity of the roof with liquid cement forced in under pressure. This method of building the side walls before the intervening soil is removed is, of course, familiar to all civil engineers, and the forcing in of cement behind a metal roof is one of the leading features of Mr. Greathead's system.

ELECTRIC LIGHTING IN THE ITALIAN NAVY.*

BY LIEUT. A. POUCHAIN.

(Concluded from page 695.)

Projectors and Search-lights.—The projectors settled upon were those of Mangin, with a reflector 40cm. in diameter. The arc lamps used in them were of two types, one being automatically fed by a small motor, whilst the other was a Sautter-Lemonnier hand regulator. The current strength in each was 50 amperes. The hand lamp requires no special description. The Mangin projector was somewhat modified with the view of reducing its weight. This was effected principally by lightening the base and supports. In the form adopted the projector, without lamp, weighed 123·2 kilogrammes, and the base 60·0, giving a total of 183·2, which was 114·6 kilogrammes lighter than the original form.

The Mangin reflector is made of crown glass, spherical in surface at the back, where it is silvered. The front is also spherical, but not concentric with the back surface, and is made to a smaller radius than the latter.

The Pasqualini automatic regulator, which was designed specially for use in the Italian navy, differs from the ordinary types in that the small motor which works it is thrown into and out of action by means of a relay, and allows the arc to be

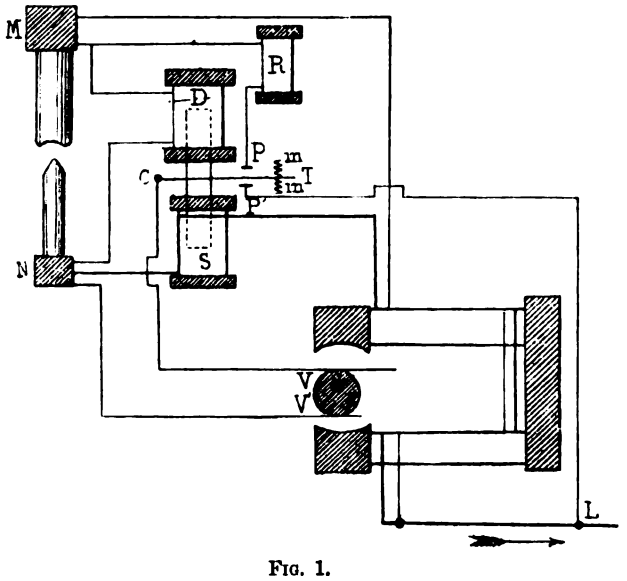

FIG. 1.

formed without the necessity for any special device for the purpose. A diagram showing the connections is given in Fig. 1, which will serve to make clear the operation of the regulator. The relay consists of two coils, one of which, D, is in shunt, and the other, S, in series with the arc. An iron core, Fig. 1 and Fig. 2, co-axial with the two coils, is supported by an arm T pivoted at C, and held in position by two springs *m m*. When the force due to the coil D exceeds that of S, the arm T comes into contact with P, and the armature of the motor is thrown into shunt with the arc, the current entering

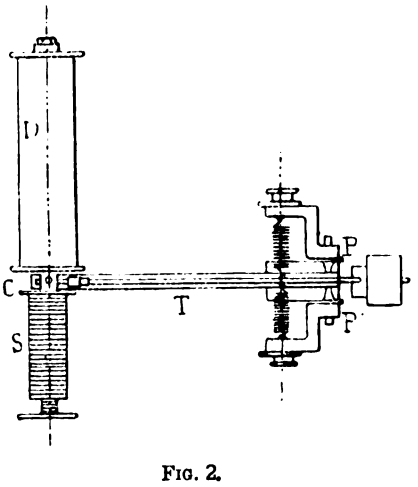

FIG. 2.

it by V and leaving by V_1. The resistance of the armature being very low, a resistance coil R (wound with doubled wire to prevent self-induction) is inserted in the circuit so as to prevent sparking. When, on the other hand, the coil S is more powerful, the arm T makes contact with P, and the armature becomes a shunt to that part of the main circuit which lies between N and L, and the current enters the armature by V_1 and leaves it by V, so that it rotates in a direction opposite to that in which it would move in the preceding case. The field-magnets of the motor have a double winding, one in series and one in shunt with the arc, so that the magnets are always

*Abstracted from the *Rivista Marittima*.

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excited, whether the arc is extinguished, when the main current is zero, or the carbons are in contact, when the difference of potential between them vanishes.

Supposing now that the lamp is put into circuit when the carbons are separated, the difference of potential between them is then a maximum, and the current is zero. The action of D is a maximum, and that of S zero. T makes contact with P, and the armature commences to rotate. This, by means of screw gearing, Fig. 3, causes the carbons to approach one another until they touch. At this moment the action of S becomes a maximum and that of D vanishes. T goes over into

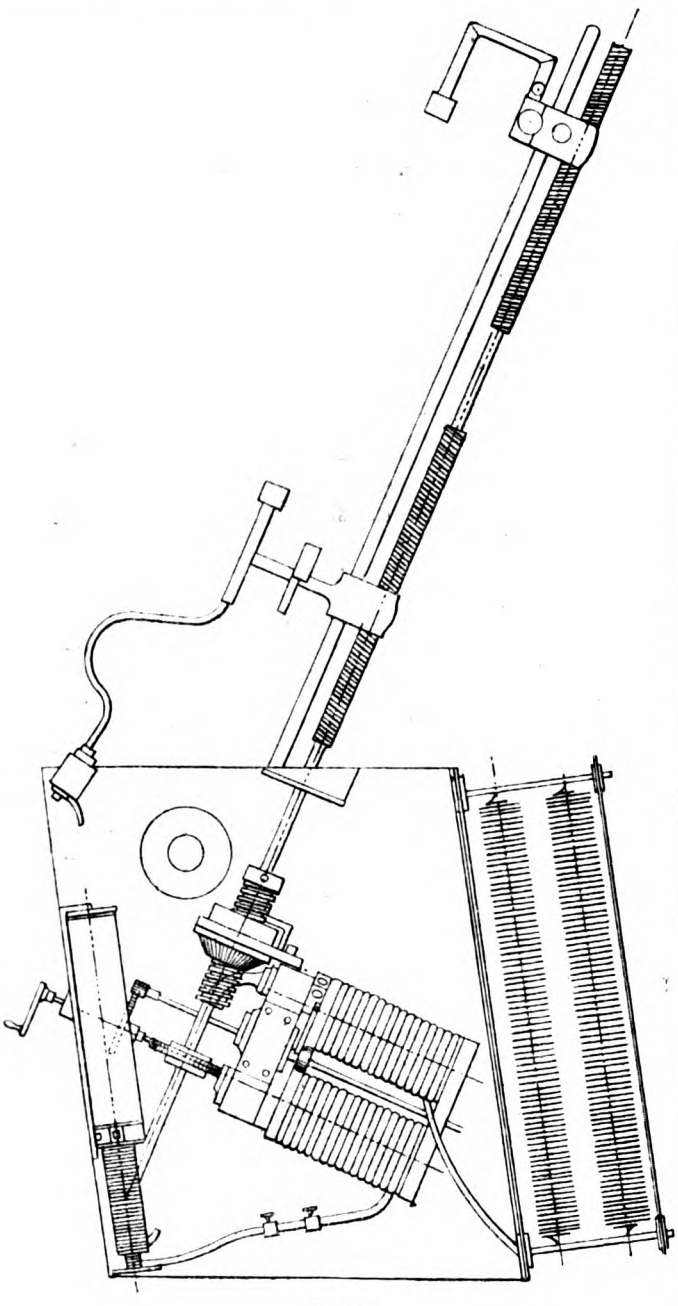

FIG. 3.

contact with P, the motor rotates in the opposite direction, thereby separating the carbons and striking the arc. The separation continues until T is enabled to take up a position of equilibrium between the two contacts.

The variations in current and tension at the arc are found with this regulator to be so small as to be imperceptible with ordinary ammeters and voltmeters.

The whole of the apparatus composing the regulator is enclosed in a case as shown at Fig. 3, and is so arranged that it can easily be applied to a hand lamp. The cost of fitting one of the latter with the Pasqualini regulator was found to be about £10.

The carbons adopted both for the hand and the automatic lamps were 18mm. in diameter. The positives were cored and 260mm. long, whilst the negatives which were plain were 145mm. long. Their durations were 9 and 18 hours respectively. Compensating resistances were supplied for compensation, of two types of 0·18 ohm and 0·30 ohm according to the length of circuit. The mean spherical luminous intensity came out at 4,500 candles, and the maximum useful range of the beam on a dark clear night was about 3,500 metres.

Incandescent Lamps.—The incandescent lamps for interior lighting in the navy were of 12-candle power on the Cruto system, by which the filaments are formed from a solution of sugar. The method of fixing the ends of the filament is as follows: to the platinum wires which pass through the glass are soldered two pieces of copper wire, and to the extremities of these a pair of small platinum tubes. These form sockets for the ends of the filament, and the joint is completed by means of a deposit of carbon obtained from coal gas. A few 25 and 100 candle-power lamps for signalling purposes were also used. All were made for a tension of 63 volts, and to consume 3·5 watts per candle; they were guaranteed for a minimum life of 800 hours, and the increase in resistance of the filaments after 500 hours' use amounted to 6 per cent. The fall in lighting power after this length of service was about 20 per cent. The holders used were of two types, the Edison screw-holder, and a spring holder like the Pieper form for use near the heavy guns.

Cables.—The leads used were of 20 different sizes; 17 of these contained 49, 19 and 7 conductors. Two contained single wires, and one was a twin cable of seven wires in each conductor. The insulation on all of these except the last was as follows:—(*a*) Cotton wound on spirally and treated with a damp-proof insulating varnish; (*b*) another layer of cotton wound spirally, or, for the larger cables, tape instead of thread; (*c*) pure india-rubber; (*d*) vulcanised rubber; (*e*) pure rubber; (*f*) tape.

The whole was vulcanised and varnished, and was either covered with a lead sheath or not, according to the locality in which it was to be placed.

The small twin cable had a special covering consisting of cotton thread and pure rubber, and was finally wound with silk. This was intended for use in the cabins only.

Casing.—The casings are of varnished teak, the covers being secured by screws, and were made in eight different sizes. The distance between the two channels varied in the different sizes from 15 down to six millimetres.

Safety Apparatus.—For the wires of the fuses placed in the leads an alloy of lead and tin was used, which, it was found by experiment, fused at the following values for the various thicknesses.

MM. diameter.	At amperes.
1·8	15
2·0	17
2·2	20
2·5	30
2·9	40
3·3	50
3·7	60
4·2	70
4·6	80
5·0	90
5·3	100

The lengths of the fuse wires were 50mm. for those on the larger cables, and 20mm. for the smaller ones. Every fuse was marked with a characteristic numeral, corresponding to that by which it was distinguished on the plan of the leads supplied.

The automatic cut-outs for the dynamos were operated by means of an electro-magnet and spring, so that when the current going through the machine exceeded a certain value the shunt magnet winding was disconnected, and the dynamo became demagnetised.

Lanterns.—These were separated into five distinct classes. These were:—(*a*) Lanterns for covered bridges, batteries, gangways, turrets, &c.; (*b*) for machine rooms and open bridges; (*c*) for ammunition rooms, &c.; (*d*) for store rooms; (*e*) for the better cabins.

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The type (*a*) is made either rectangular or round, the framework being of bronze, and a reflector, corrugated in the round form and concave in the rectangular one, being placed behind the lamp.

The type (*b*) is also made in two forms, either portable or fixed; it consists of a cylindrical glass shade, with hemispherical end, on a wooden base if fixed, and with gun metal guard if portable.

The (*c*) lantern was adapted either to be placed in recesses in bulkheads when it had a flat glass face to come flush with the wall, or else it was provided with a hemispheric glass and meant to be fitted to the underside of the deck.

For store rooms the lamps were either made rectangular with double glass face or were placed under pear-shaped globes and mounted on arms.

The (*e*) types were supported by silvered pedestals, or arms, and furnished with frosted glass shades.

Switches and Sockets.—Four types of switches are in use. (*a*) with a removable handle for a large number of lamps on one circuit; (*b*) with fixed handle for 1 to 10 lamps; (*c*) similar to the last, but with movable handle, and (*d*) a pear-shaped switch in wood, for use with flexibles in the cabins. The working parts of all these switches were calculated for a current density of half an ampere per square millimetre. Classified with these were a short circuiting key for ammeters and a two-way switch mounted on porcelain like the rest.

The sockets used are of three types adapted for portable lamps on covered bridges, for auxiliary projectors and for portable lamps in the open and engine rooms respectively.

Ammeters and Voltmeters.—These at present are of the Deprez-Carpentier make, but this selection is only to be considered as provisional. The ammeters register to 100, 150, 200 and 300 amperes, and the voltmeters to 100 volts.

Distributing Board.—The distributing board consists of two sets of brass bars. The bars of one set are placed horizontally and connected to the poles of the machine, the leads being taken from the vertical bars. Connection between the two sets is made by means of plugs in the usual manner. The sections are calculated to give current densities not exceeding one ampere per square millimetre. The main fuses are situated not on the distributing board but in close proximity to it, as are also the proof lamps for each circuit. The board is divided into two halves along a vertical line, one part being assigned to the projectors, and the other working the interior lighting and the signalling apparatus. A diagram, showing the system of distribution on every ship, is mounted on a teak board and fixed to a bulkhead close to the distributing board.

Organisation of the Service.—A choice of the plant to be used in the Royal Italian navy having been arrived at, regulations were drawn up with regard to running the plant and conducting the service with the objects of eliminating any differences between the various ships, and of rendering the whole arrangements easy of control by the authorities. The management of the electric lighting service was put into the hands of the General Direction of Artillery of the Ministry of Marine, and under them of the Local Direction of Artillery and Torpedo Service. The head electro-technical offices were associated with the direction of the artillery and torpedo services of the 1st Department, and had to undertake experiments and tests on plant, the preparation of plans for the whole navy, and the management of repairs for all the ships. Under this head office others were organised to work in conjunction with other departments of the direction of the artillery and torpedo services. A specially qualified staff was selected from the various departmental branches, and workmen in sufficient numbers were allotted for the work in hand. On board the vessels the electrical service was entrusted, under the commander, to the electrical torpedo staff, and the subsidiary boilers to the ship's engineers.

The papers drawn up to serve as a guide in the administration of the service, and to secure uniformity, &c., consisted of the following:—(1) Regulations regarding electrical plant in the Royal Navy; (2) A schedule containing the data of every machine; (3) A journal showing the work of every machine; (4) A detailed account giving full particulars as to the work of every machine, the number of lights running, &c.; (5) A full list of all leads, lamps, and subsidiary apparatus on board; (6) Instructions as to the maintenance of the plant in proper working order.

Electrical Staff.—As soon as the applications of electricity to naval warfare began to make such rapid progress it was considered desirable that every officer in the torpedo service should possess a knowledge of electro-technology. As individuals with these qualifications were not forthcoming in sufficient numbers, a course of study in this branch was included in the curriculum of the Final Naval School at San Bartolomeo, Spezzia. As has been already mentioned, a laboratory in connection with the First Department of the Direction of the Artillery and Torpedo Service was also instituted. Part of the building at San Bartolomeo was set aside for this purpose, and was equipped with all necessary machines and apparatus.

LEEDS ELECTRIC TRAMWAY.

Yesterday afternoon the first overhead-wire tramway in England—or, as it is called in America, trolley line—was inaugurated. The line runs from Burmantofts to Roundhay Park, Leeds. Several trials have been made during the last few days preparatory to opening the line for public traffic early next week. The system adopted is based on the Van Depoele and Thomson-Houston patents, and includes all the latest improvements in details suggested by the experience of the Company in their extensive electric tramway operations in America.

The generating station and car shed is situated about the middle of the line, which is over three miles in length. At present the generating plant consists of a Babcock and Willcox 190 H.P. boiler fitted with mechanical stoker, and a single cylinder 18in. by 18½in. high-pressure engine by McIntosh and Seymour, of Albany, U.S.A., which indicates 200 H.P. at 100lb. steam pressure, and which drives by belts two Thomson-Houston compound-wound dynamos, having each an output of 62,000 watts at 900 revolutions per minute. The current from the dynamos is taken to a special switchboard, designed by Mr. Winslow, of the Thomson-Houston Company, fitted with rheostat regulators and measuring instruments for each dynamo, and an automatic circuit-breaker to prevent overload. This circuit-breaker is an electro-magnetic cut-out arrangement, the circuit being broken when the current in the main reaches a certain strength, and the arc formed on breaking circuit is blown out by Prof. Thomson's well-known device.

The conductor by which the current is conveyed to the car motors is of hard-drawn copper of No. 0 B.W.G. (·34in.), and is suspended about 20ft. above the track level by insulators from galvanised steel suspension wires (No. 5 B.W.G.), which cross the track at right angles, and are fixed to mild steel poles 21ft. 6in. high at either side of the roadway. These are made up of three lengths, 6in. diameter at the bottom and tapering to 4in. at the top. They are set in concrete to a depth of 6ft. The method of fixing the conductor to the suspension wires is rather ingenious. The suspension wires from the poles are fixed to the two ends of a ram's-horn shaped casting, through the conical hole, in the centre of which is passed a bolt having a hard rubber head. A hard rubber conical washer, screwed up tight into the conical hole, fixes the bolt firmly to the suspension. On the end of the bolt is screwed the cap of a copper ear, with a groove underneath, along which the conductor is soldered. The suspension wires, as an extra precaution, are insulated from the poles in the ordinary way. Two feeders of insulated single wire (No. 0000 A.W.G. = ·46in. diameter) carry the current from the generating station to Roundhay-road, and from there one feeder of No. 00 A.W.G. (·365in.) runs along the track. The rails are connected together electrically by the simple device used by Mr. Holroyd Smith at Blackpool. A hole is made at the end of each rail, a piece of No. 7 B.W.G. wire is passed through, connecting two rails together, and the joint is completed by driving in a taper steel pin. The volts at the dynamo terminals are 300, and the maximum working

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volts of motors about 270, 10 per cent. being allowed for fall on the feeders. The current is carried from the conductor to the motors by an under-running trolley wheel of gun metal, 4½in. diameter, fixed on the end of a long lever, which is hinged at the middle of the car roof. A set of six spiral springs, in extension, pulling on the other end of the lever, maintains contact between the trolley and conductor. There are a number of sidings along the single track, and consequently at these places it is necessary that the current-carrying conductor should branch in order to supply current to motors on the two lines. At each branching the conductor is attached to a right or left hand frog, as the case may be, which guides the trolley to one side or the other, according to the side taken by the car.

Each car is fitted with two single-reduction motors of 15 H.P. each. The makers' designation of the motors is S R.G. 30, type B. They are designed for use with 30in. wheels. The weight of each motor without gear or gear cover is nearly 18½cwt. The armature with pinion weighs 4cwt. 36lb; each field coil, 1cwt. 16lb.; each pole, 2cwt. 46lb.; the casting connecting the armature bearings with the axle, 6cwt. 21lb. The weight of the axle gear is 1cwt. 3qr. 19lb. The motors, which are series-wound machines and are coupled in parallel with each other, are suspended directly on the axle, and geared with cut steel gearing. The reduction ratio is about 4⅔ to 1, the number of teeth in the pinion on the motor shaft being 14, and the number of teeth in wheel on car axle being 67. The gear runs in oil. A flexible suspension, consisting of coach springs and rubber washers in compression under the field magnets of the motor, prevents jarring of the motor on starting. The regulation is effected by means of a rheostat under the control of the driver. The cars, of which there are at present six, were made in New York, and weigh six tons each when unloaded. They are necessarily of the single-deck type, and are constructed to carry 22 passengers. Each car is lighted by five incandescent lamps in series. The fittings and finish of the cars are very handsome. At the terminus there are four tracks, for the accommodation of 12 cars. A pit at one end, 30ft. by 40ft., enables four cars at a time to be examined.

The track on which these cars will run extends over three and a-quarter miles, starting from a thickly populated part of the town, and passing through a suburban district to Roundhay Park, the property of the Corporation. Of this length two miles of the track is double line, and the remaining one and a-quarter miles is single. The double line has been in use for some time, a service of steam tramways having been temporarily placed on it. The single track line is new, and is constructed of 98lb. girder rail laid in concrete. The heaviest gradients are two of 1 in 20, each about 1,000 feet long, and there is another of 1 in 33, about 2,000 feet in length. There seems to be a promise of good traffic, as there is no great competition in the neighbourhood, and there is every reason to suppose that the line will be a mechanical and electrical success. Every care seems to have been taken, in the construction of the line, cars, motors, and generating plant, that the workmanship should be unexceptionable.

THE CHICAGO EXHIBITION.

The following prospectus has been sent us for publication :—

Under date of the 27th August, 1891, Her Majesty was pleased to issue a Commission to the Council of the Society of Arts, authorising them to act as Commissioners for the Universal Exhibition, which, pursuant to an Act of Congress, and in accordance with a proclamation made by the President of the United States of America, will be held at Chicago, from May 1 to October 30, 1893. The Royal Commission are now prepared to receive applications from artists, manufacturers, and others desirous of taking part in the Exhibition, to afford them the necessary information, and to offer them all available facilities which they may desire for this purpose. Such applications must be made upon forms to be obtained from the Secretary of the Commission, at their Offices, Society of Arts, John street, Adelphi, London, W.C. They must be sent in properly filled up, not later than February 29, 1892, and addressed to the Secretary as above.

As the funds granted by H.M. Government will not suffice to defray all the expenses of the Section, it is necessary that they should be supplemented by payments from the exhibitors. A charge will therefore be made to each exhibitor, based on the amount of space occupied, and calculated on the following scale :—

						s.	d.	
For spaces not exceeding 100 sq. ft.						5	0	per sq. ft.
For spaces exceeding 100 sq. ft. and not exceeding 200 sq. ft.						4	6	„
„	„	200	„	„	300 „	4	0	„
„	„	300	„	„	500 „	3	6	„
„	„	500	„	„	750 „	3	0	„
„	„	750	„	and upwards		2	6	„

The minimum charge will be £5.

It is not expected that the total receipts from all sources will more than suffice to defray the cost of an adequate representation of British industry; but should there be a sufficient surplus after the payment of all the costs of the Section, the Royal Commission will refund the balance *pro ratâ* with the amounts contributed by the several exhibitors. The amount produced by the payments of exhibitors will, therefore, be treated as a guarantee fund, to be expended if necessary, but if not to be refunded to the contributors.

The Exhibition is situated in Jackson Park, within the southern limits of the city of Chicago. The principal buildings are devoted to the following main divisions :—(1) Fine Arts; (2) Manufactures and Liberal Arts; (3) Agriculture; (4) Machinery; (5) Electricity; (6) Mines; (7) Transportation; (8) Horticulture. In all these space has been allotted to Great Britain, though it is expected that the principal British Court will be that in the building of Manufactures and Liberal Arts, since the privilege has been conceded to this country of massing all, or most, of its exhibits together, should such a course prove desirable.

Exhibitors' goods will be transmitted direct in bond to Chicago, where the usual Customs examination will be made. Goods for exhibition only will not be liable to duty, but on goods sold the usual rates will have to be paid. Goods can be sold in bond, at prices independent of the tariff, the duties being payable by the purchaser.

The American Railroad Companies propose to carry goods back from the Exhibition free, charging the usual rates for the outgoing journey. These rates, it may be noted, are low in comparison with those usual in European countries. It is hoped that special terms for Exhibition goods traffic may be obtained from the Atlantic Steamship Companies. Full information as to routes, traffic rates, &c., will be provided in due course.

A general Official Catalogue will be published in English, French, German, and Spanish. A special catalogue will also be published for the British section. Exhibitions of live stock will be held, and prizes will be offered in connection with them. A special circular has been issued, giving information about these.

A limited quantity of steam and water power will be supplied gratuitously. Further supplies will be provided at a fixed rate. Countershafts, pulleys, belts, &c., must be provided by the exhibitor. Application for motive power must be made on special forms, which will be supplied on demand.

The general reception of articles at the Exhibition buildings will commence on November 1, 1892, and no articles will be admitted after April 10, 1893. Foundations for heavy machinery may be put in, and special constructive work commenced, as soon as the state of the ground and the buildings permits.

Special regulations will be hereafter issued for the organisation of the international juries.

The Royal Commission are informed that the contract labour laws of the United States will not prevent exhibitors from importing foreign labour, or from entering into binding contracts with their *employés*. Further information on this head will be supplied on application.

Every person who becomes an exhibitor in the British section thereby agrees to be governed by the rules and regulations laid down by the Exhibition Executive, or by the Royal Commission through its executive officer.

The following classification has been adopted :—

Department A.—*Agriculture, Forest Products, and Forestry—Machinery and Appliances.*

Department B.—*Viticulture, Horticulture, Floriculture.*

Department C.—*Live Stock—Domestic and Wild Animals.*

Department D.—*Fish, Fisheries, Fish Products, and Apparatus of Fishing.*

Department E.—*Mines, Mining, and Metallurgy.*—Group 55: Boring and drilling tools and machinery, and apparatus for breaking out ore and coal. Group 56: Pumps, engines, and apparatus used in mining for pumping, draining, and hoisting.

Department F.—*Machinery.*—Group 78: Electric welding, forging, riveting, shaping, tempering, and brazing metals. (See also Department J.)

Department G.—*Transportation—Railways, Vessels, Vehicles.* Group 31: Electric Railways.

Department H.—*Manufactures*—Group 108: Rubber goods, caoutchouc, gutta-percha, celluloid, and zylonite.

Department J.—*Electricity.*—Group 119: Apparatus to illustrate the phenomena and laws of electricity and magnetism. Group 120: Thermo-electric batteries. Group 121: Electrical batteries, secondary or "storage" batteries. Group 122: Machines and appliances for producing electrical currents by mechanical power—dynamos. Group 123: Transmission and regulation of the electrical current. Group 124: Electric motors and their applications. Group 125: Lighting by electricity. Group 126: Heating by electricity. Group 127: Electro-metallurgy and electro-chemistry. Group 128: Electric forging, welding, shaping, tempering,

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brazing, &c. Group 129: Electric telegraph and electric signals. Group 130: The telephone and its appliances. Group 131: The phonograph. Group 132: Electricity in surgery and therapeutics. Group 133: Applications of electricity in various ways not before specified. Group 134: History and statistics of electrical invention.

DEPARTMENT K.—*Fine Arts—Pictorial, Plastic, and Decorative.*

DEPARTMENT L.—*Liberal Arts — Education, Literature, Engineering, Public Works, Music, and the Drama.*

DEPARTMENT M.—*Ethnology, Archæology, Progress of Labour and Invention.*

The Royal Commission is composed as follows:—The Prince of Wales (President of the Society of Arts); the Attorney-General (Vice-President and Chairman of the Council of the Society); Sir Frederick Bramwell (Vice-President and Deputy-Chairman of the Society); the Duke of Edinburgh, the Duke of Clarence and Avondale, Sir Frederick Abel, the Duke of Abercorn, Mr. William Anderson, Sir Francis Dillon Bell, Sir George Birdwood, Sir Edward, Birkbeck, Major-Gen. Sir Owen Tudor Burne (Vice-Presidents); Mr. Michael Carteighe; Dr. R. Brudenell Carter, Lord Alfred S. Churchill (Vice-Presidents); Mr. B. Francis Cobb (Treasurer); Sir Philip Cunliffe-Owen, Prof. James Dewar, Major-Gen. J. F. D. Donnelly (Vice-Presidents); Sir James N. Douglass; Sir Henry Doulton (Vice-President); Mr. James Dredge, Mr. Francis Elgar; Mr. James Staats Forbes, Sir Douglas Galton, Mr. Thomas Hawksley (Vice-Presidents); Mr. Alexander B. W. Kennedy, Mr. Charles Malcolm Kennedy, Mr. John Biddulph Martin, Mr. George Matthey, Mr. John Fletcher Moulton; Sir Henry F. Ponsonby, Mr. Wyndham S. Portal (Vice-Presidents); Mr. William Henry Preece; Sir Robert Rawlinson (Vice-President); Prof. William Chandler Roberts-Austen; Sir Owen Roberts (Treasurer); Sir Saul Samuel; Sir Henry Trueman Wood (Secretary); Messrs. Henry B. Wheatley and E. H. Lloyd (Assistant Secretaries).

THE LINK SWITCH.

The necessity for a really reliable electric light switch has been fully recognised by electrical engineers and by that section of the public which is keenly interested in trustworthy appliances that never get out of order. Notwithstanding the constant demand for such a perfect switch, and despite the fact that patents and specialities are numberless, improvements are continually being introduced. One of the best examples, and one which has deservedly met with the approval of the users, is generally known as the "tumbler switch," and is actuated by a rocking lever which depresses an insulated contact bar, pivoted at one end, against the force of a spring. The contact pieces, or brushes, are electrically connected by the metallic end of the contact bar when it is depressed. When the rocking lever is turned in the opposite direction the elasticity of the spring raises the contact bar and breaks the circuit. It is obvious that if the spring becomes weakened or the contact bar should stick, the circuit cannot be broken by any movement of the rocking lever. This is a serious disadvantage, and attempts are sometimes made to avoid it, by the use of light spring contacts. A new switch of this particular type, but constituting a distinct improvement upon the "tumbler switch," has been brought out recently by "The General Electric Company (Limited)," and patented by Mr. G. Binswanger, and which we will briefly describe.

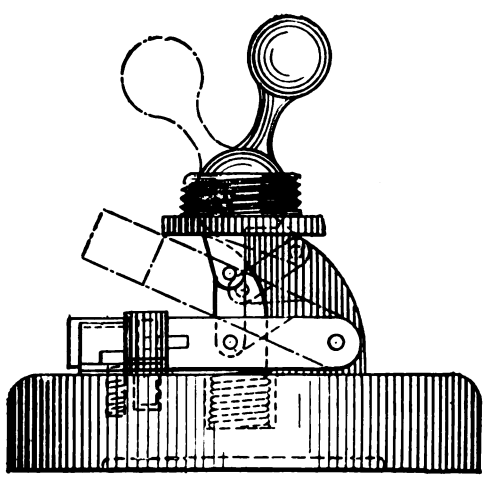

FIG. 1.

Fig. 1 is an elevation of a small "link switch," with the protecting cover removed. The handle is pivoted to a bracket attached to the base, and the contact bar pivoted at one end engages with stout contact pieces when the switch is in the "on" position. The handle is connected to the contact-bar by a toggle joint, consisting of a link jointed to both. The spiral spring is placed under the contact-bar, so that when this is depressed it is locked, owing to the joints of the toggle being in line. The dotted outline shows the "off" position, and it is obvious that the connection of the contact-bar with the rocking lever by means of the link enables the movement of the rocking lever to mechanically pull the contact bar out of contact, *independently* of the action of the spring and *in spite of* any sticking of the contacts. Fig. 2 is an elevation of a double pole, or multiple contact "link switch," in which the contact-bars are connected to the link by a transverse bar rigidly attached to all the bars. A modification is shown by the sectional elevation (Fig. 3), in which the cam or handle presses down the contact bar, and the link is *not* jointed to it, but is jointed to the contact-bar, and works freely within a slot in the lever-handle, a stop preventing it from becoming disengaged. Ordinarily this link is inoperative, since the spring alone raises the contact-bar when the rocking lever is thrown over. Should the spring fail to act properly, or the contacts adhere beyond its lifting power, the stop engages with the edges of the slot in the lever-handle, and the contact-bar is raised mechanically, as in the instances already cited. This pattern of switch will therefore snap off, and prevent any attempt to turn the lamp half down, a common cause of damage to switches.

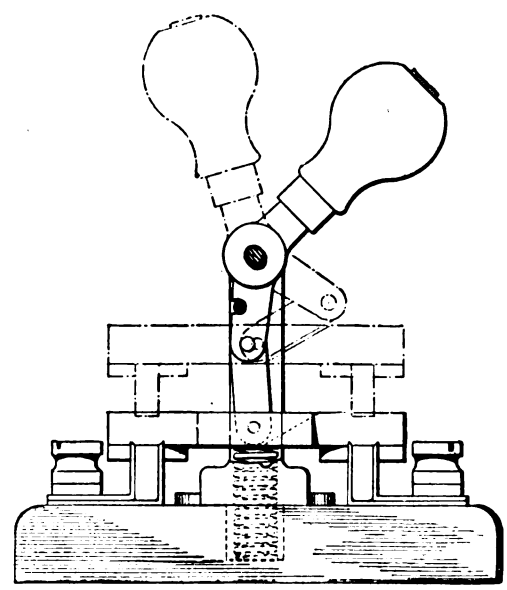

FIG. 2.

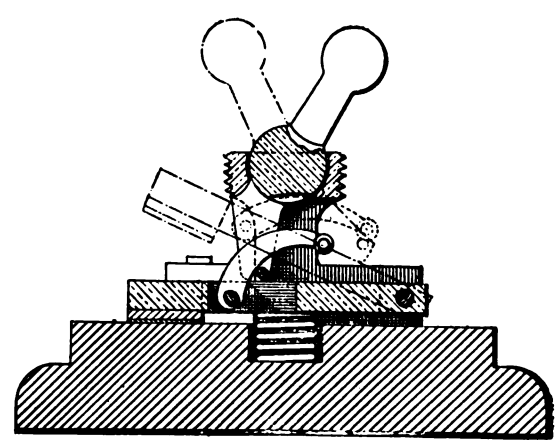

FIG. 3.

It will be seen that the mechanism is extremely simple, and not liable to derangement, while the mechanical action ensures the proper and effective working of the switch. The end of the contact bar is made of solid brass, and wedged in firmly between the two contact brushes, thus ensuring a much better contact than in those switches which rely on the action of a spring to open the circuit.

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THE GOVERNMENT AND THE TELEPHONES.

The following letter, which appeared in *The Times* of Monday, will be of interest. We are glad to see that the writer is emphatically of opinion that the matter is too important a one to be left to drift:—

TO THE EDITOR OF THE TIMES.

SIR: Since my return to London I have read the correspondence that took place a few weeks ago in *The Times*, and the comments of the electrical journals on the proposed new departure as to telephones.

I am not a shareholder in, and have no direct or indirect financial interest in, any telephone company; but I have used the telephone for several years, and, in common with all who use it, I am interested in the discussion which took place in your columns during the vacation. The service in London is not perfect, yet it is most useful, and has been much improved since the amalgamation of the Companies, and doubtless every improvement that can be made, under existing conditions, will be effected by the able men who direct the National Telephone Company.

Mr. Bennett's wish is to establish an ideal telephone service at very low rates of subscription, and naturally we all wish to have such a service. Many practical men say, and the electrical papers seem to agree, that Mr. Bennett's plan, so far as he has made it known, cannot be made commercially successful. It is certainly strange that the National Telephone Company should have allowed Mr. Bennett to leave their employment, if they believed he could render their service many times more efficient than it now is, while reducing the cost to subscribers, and at the same time enabling the Company to earn larger dividends than they are now doing.

I have no wish to enter into the merits of the existing system as compared with that suggested by Mr. Bennett and others; for it seems to me that a very important public question is involved in this matter of telephones—one which concerns the good faith of the Government.

Shortly after the Telephone Company started, the Post Office brought an action against that company, claiming a monopoly of telephonic, as well as of telegraphic, communication. It is well known that the decision of the Court of first instance was in favour of the Government; but it was felt at the time, and is felt by lawyers and others still, that if the Company had appealed the decision of the Court of first instance would almost certainly have been upset. The Post Office, however, offered the Telephone Company a licence for 30 years, on their paying a royalty of 10 per cent.; the company not having much money, and shrinking from a costly legal fight against the Government, accepted those terms; and on the strength of this long licence, far more than on their patents, a capital of more than two and a-half millions of pounds has actually been paid by the shareholders and expended in the development of the system from the crude state in which it was when they commenced business.

It seems now that the National Telephone Company is threatened with the active opposition of other companies licensed by the Post Office, and even by the Post Office itself. There is to be free trade in telephones in England, in face of the partnership in profits which exists between the Post Office and the National Telephone Company.

As the Telephone Company has not taken any part in the correspondence in *The Times*, I presume we are right in thinking that they are not seriously afraid of this competition. Perhaps they are right, inasmuch as at enormous expense they have got trunk lines all over England and Scotland, and it does not seem probable that any other company will be able to get trunk lines throughout the kingdom at much less cost than has already been paid by the National Telephone Company, and that therefore it is hardly probable that there will be any second trunk line through the kingdom. If the Government establish or favour another trunk system it can hardly be expected to pay.

But, Sir, cannot we take, and ought we not to take, this discussion as to the future of the telephone in England out of the domain of rival companies, and ought we not to look fairly in the face the question of the Government buying up the existing telephone companies, or, if they refuse to buy, then standing aside and allowing their responsible licensee to carry out the business for which they are licensed by the company, on the good faith of which compromise the very large capital has been raised and spent?

Mr. Preece, the Post Office adviser in such matters, said in his address before the International Electrical Congress at Frankfort in September last, "In a commercial country like England an invention to attract attention and to prosper must be patented. It must have the prospect of great gains to attract capital. It must, therefore, be developed by private enterprise. When a new industry has thus been developed, and when it affects the public weal, Government is forced to step in and take the control of it." I have never seen the licence which the Government granted; it is, however, common knowledge that the Government reserved to itself the right to purchase the telephone companies at certain periods, one of which expired on June 30th last. Ought not the Government to have exercised this right in June last? I judge from what Mr. Preece said at Frankfort that the Post Office, wisely realising the importance of acquiring the telephones, and knowing they would never again buy them up so cheaply, were in favour of exercising their right of purchasing on June 30th last; but, as the purchase was not made, I suppose this wise policy was overruled by the Treasury. I presume that, the period having elapsed, the Government have lost their absolute right to purchase the telephones in the present year. Surely, however, it will be better that they should approach the Telephone Company, and arrange to purchase all their interests under the conditions of the licence, rather than that we should have an unseemly quarrel, and a number of rival companies starting, very few, if any of them, ever paying a dividend. Moreover, is it right that a Government department, having granted a licence, under which they benefit largely, and in consequence of which two and a-half million sovereigns have been raised, should throw obstacles in the way of or even trade against their licensees?

We all want a perfect telephonic system. The Government could establish such a system better than any one else; and, best of all, the telephone department of the Post Office would pay well, for the National Telephone Company is paying well. The rental for the year ending April 30, 1890, was given in *The Electrician* as £364,704. 17s. 5d., and for the year ending April 30, 1891, at £422,378. 6s. 2d.; the balance to the credit of net revenue this year is given as £194,821. 8s. 1d.

The Government could do, at any rate, as well, perhaps better, as they can raise the necessary stock at a cheaper rate than any company. If the Government do not buy now, it will cost them very much more to acquire all the telephone companies at some future date, and this will be a great mistake. I do not know whether the Telephone Company wishes to sell; I feel sure that it will be for the public advantage that the Government should purchase.—I remain your obedient servant, S.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *October* 16, 1891.

The Street Railway Convention at Pittsburgh.—Everything indicates that the Street Railway Convention, to be held in Pittsburgh next week, will be a thorough success. The exhibits at the last Convention in Buffalo were remarkably fine, and even more is promised for the present Convention. Not only the great electrical companies, but the electric supply dealers and the manufacturers of trucks and other general street-car machinery, will be out in full force with exhibits. One of the interesting things promised is the new Thomson-Houston iron-clad single-reduction gear motor, of which I wrote you several weeks ago. It is known to the trade as the "W.P." (water-proof), from the remarkably complete manner in which it is cased in by its own magnetic circuit. Originally designed for a narrow-gauge machine, it has now taken its place as one of the standard motors, and is likely in a considerable measure to take the place of the Thomson-Houston regular "S.R.G." machine. The armature, a powerful toothed ring, gives plenty of torque, and is very efficient, even at its low rotative speed; and the only objectionable feature of the machine is the one-sidedness of the magnetic circuit, which, however, appears to produce no serious results, and has one advantage, that is a tendency to lessen wear on the bearings by the magnetic pull relieving part of the weight of the armature.

The New Edison System of Electric Traction.—Meanwhile the papers have been full of vague talk concerning the marvellous new system of electric traction about to be devised by the "Wizard of Menlo Park," who, by the way, has not lived there for some years. Simmered down, this marvellous invention appears to be, as I hinted in my last letter, a modification of Edison's old scheme of supplying the current from the rails at a very low pressure, feeding sections of rail by continuous-current transformers. Several years ago when he was working along the same line the inventor stated that by the use of a very low voltage he had been able to reduce the leakage current to 5 H.P. per mile of track, even in bad weather. Altogether it appears to be a case of "much cry and little wool" up to date, although it has undoubtedly caused some street railway men to hesitate about taking up any of the present systems.

The Stanley Alternating Motor.—It is reported that the next 30 days will see the Stanley alternating-current motor, of which I wrote you some months ago, on the market in working form and in sizes as high, perhaps, as 5 H.P. You will remember that this machine does not differ from the ordinary direct-current motor with the laminated field, except that a condenser in the field circuit annuls the self-induction and allows the magnetism to be properly developed. The machines run well, and start apparently as freely as their direct-current counterparts, but their efficiency must necessarily be somewhat lower. In a 1 H.P. motor, for example, running with currents at the frequencies generally employed, it would be a difficult matter to bring the hysteresis much, if anything, below 100 watts, particularly as the property of constant self-induction required for the proper action

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of the condenser compels the use of a powerful field magnet. He employs a motor and dynamo directly and intimately connected, both machines are shunt wound, the fields are in series with each other, so that the strength of the two fields varies together, while the armature circuits which are independent of the fields are also in series with each other. A rheostat placed in the joint field circuit controls the current passing through it. As a result, the speed of the motor armature can be very nicely regulated and will remain constant at any given speed under varying load. Dropping off the electromotive force of supply enables the motor to work with a fair efficiency, even at low speed, while the current through the armatures necessarily varies according to the load. The fundamental idea is by changing the electromotive force of supply to vary the current in proportion to the work.

PARIS NOTES.

(FROM OUR SPECIAL CORRESPONDENT.)

PARIS, *October* 26, 1891.

Accumulator cars will shortly be given a trial on a large scale in Paris. The line chosen for the experiment is one belonging to the Compagnie des Tramways Nord, and running from the Opera House to St. Denis, a distance of about six kilometres. Between the Rue du Faubourg Montmartre and the Rue Rochechouart there is a 5·5 per cent. gradient some 400 metres long. The Compagnie des Tramways are to pay the Société Électrique 16 centimes per car-kilometre (say, 2½d. per car-mile). Laurent-Cély accumulators, made by the Société pour le Travail Électrique des Métaux, will be employed. Accumulator cars are also to be employed by the Lyons Tramway Company. These cars are fitted with 112 Faure-Sellon-Volckmar cells, Gall steel chain gearing and Alioth motors being used.

Messrs. Rothschild have placed the sum of 175,000 francs at the service of MM. Hutin and Leblanc, to enable them to carry out experiments on a commercial scale on their rotating field motor. Let me remind your readers that the Hutin-Leblanc motor has the advantage of only requiring two wires, and that the rotating field is produced by two groups of coils connected in parallel across the alternate-current mains, a condenser being interposed in one of the groups. The revolving armature consists of two inter-crossed polygonal windings, each comprising eight coils. The ends of these windings are connected to three rings, one of which is common to the two circuits. Three brushes bear upon these rings. These brushes are connected to two rheostats, which enable one to switch more or less resistance into either of the armature circuits. On starting, it is advisable to make the resistance very high, in order to increase the torque.

The Boulevard Barbès, in the vicinity of the Gare du Nord, has just been lit up by arc lamps, arranged two in series across a 110-volt circuit. The same style of post as is used on the Boulevard Sébastopol has been adopted. This particular pattern, I may add, is being everywhere substituted for the various experimental types erected in the different sectors.

The accounts of the Compagnie Parisienne de l'Air Comprimé (Système V. Popp) published on the 27th ult., show a deficit of 307,709fr. The Directors explain this state of things by saying that the Company has been obliged to greatly modify its organisation, owing to the failure of various arrangements; and they further state that the plant has fallen into bad repair, owing to the fact that the staff has been entirely occupied in laying mains in the district allotted to the Company within the time allowed by its concession. In some of the Popp Company's stations continuous-current transformers are being installed, and it is intended to run these in parallel with the accumulators.

The system of telephonic messages received a great impetus last month by its extension to the whole of Paris. In August the number of messages telephoned amounted to 5,400, while in September 9,017 were sent. For a sum of 50 centimes one may telephone to the exchange nearest the addressee, where the message is reduced to writing and delivered by a messenger boy.

Interurban telephony continues to grow in favour. The latest additions to our trunk wire system are the lines connecting Bordeaux with Arcachon (60 kilometres), and Vienne with Lyons (30 kilometres). The Toulouse exchange has also come into operation.

Esslingen.—At a meeting on the 13th inst., the municipality of Esslingen granted a concession for the supply of electric light and power in that town for twenty years to the Maschinenfabrik, Esslingen.

CORRESPONDENCE.

MULTIPHASE CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: If Mr. Kapp expects by his letter of the 17th to draw me into a hostile controversy, he must remember that it takes two to make a quarrel, and I esteem him far too highly to care to be one of the two. Mr. Kapp has, I fear, misread my British Association Paper; he has certainly mistaken the object of that part which referred to the Lauffen experiment, which was in the interests of those pioneers, to preserve their well-wishers from the disappointment prepared by the well-meaning but sensational penny-a-liner.

I was also anxious to support the claims of Tesla secured by his twenty-five American patents on this subject, and the practical results of whose work I have examined and tested in America, though they are little known here. I had a remarkable proof of the necessity in all fairness of doing so, for one of the greatest electrical authorities confessed to me yesterday his ignorance of the fact that the dynamo used with Tesla's motors generated separate currents of distinct phases.

I also desired to make it known that the pioneers at Lauffen did not claim any new invention in the plan of using a rotating magnetic field, and that the experiments were chiefly interesting in that they tested the possibility of maintaining high tension over a long distance of bare wire.

The sensational writers had proclaimed that these motors were a great advance in principle on Tesla's, that there was less lag and greater starting torque, and that for transmission of power by alternating currents they offered the only practical solution. This was unfair on the pioneers, who will always be given the highest possible credit for the good work they really have done. They are the Allgemeine Elektricitäts Gesellschaft and their staff, the Oerlikon works, and last but by no means least Mr. C. E. L. Brown, a man whose rare constructive ability is coupled with the utmost fairness to other inventors, and whose letter in your last isssue is like a summary of my British Association remarks.

Neither Brown, Tesla, nor myself are likely to be found among the scoffers; and when Mr. Kapp calmly reviews the situation, I am pretty sure he will find that his sentiments do not differ from those of the rest of us.—I am, &c.,

34, Great George-street, Westminster. GEORGE FORBES.

THE BROWN ROTARY ENGINE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I noticed with much pleasure the critical tone of the article, in your issue of the 9th inst., on the Brown Rotary Engine, which has recently been receiving more attention of a certain kind than its merits deserve. The report upon it by Prof. Jamieson has been well distributed, and doubtless has proved a fairly successful advertisement for the purpose intended; but it is not at all what we ought to expect from its author. At least it does not seem to me that this report, judiciously omitting any critical references to the mechanism, and amplifying and appropriating advantages common to rotary engines in general, although it may be admirable from the one point of view, is conceived in a proper spirit of fairness to the mechanical world which esteems the Professor among its leading lights. Surely he forgot his well-earned repute when giving his unqualified approval—indirectly only be it observed, yet approval practically—to the absurd mechanism of this engine. For in face of the records of past experience in this connection, it were but silly temporising to apply a less vigorous term. By anyone who has devoted any study at all to the science of mechanism the contrivance can only be regarded as another example of misguided ingenuity; and the most lenient criticism that can conscientiously be vouchsafed it is to admit it to be evidently of most careful and excellent workmanship, but of a radically bad design.

However, the very best of modern workshop practice could not effect an actual cure of the manifold hereditary diseases with which the device is afflicted. Based upon a mechanically

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faulty principle, and of very near resemblance indeed to some of the most primitive of inventions in this line, such an engine may likely enough be machined to a sufficient perfection to show fair results at the commencement of its career; but it is impossible to entertain the least hope of its maintaining this efficiency for any duration of time under the ordinary conditions of use.

It is not necessary here to go fully into the reasons for this adverse opinion, for these become sufficiently apparent on consideration of the design. But in the *English Mechanic* two or three years ago I discussed this subject with more detail, and I then pointed out some very potent reasons for the long unbroken series of failures with rotary engines of this class. I should explain that I adopted a method of classification, not a mathematical classification as Reauleaux's, but one based more on mechanical lines easily recognisable without analytical investigation of the mechanism. On this system I grouped engines of the type in question under what I designated the cam class; and I showed that, although the most honoured of inventions, this class of engine has actually about the least practical utility of any for the purpose of fluid pressure engines, for the obvious reason that a cam surface cannot be effectively packed. The only obstacle offered to leakage consists of a mathematical line of contact between the non-coincident, or, as Reauleaux puts it, higher paired surfaces of the cam and packing. This alone is a fatal condemnation of the class, and the defect is emphasised by wear; whereas coincident or lower paired surfaces, which are the only true packing agents worthy of recognition of the engineer, generally tend to make a more perfect and steamtight contact.

Enough of the mechanical ineptitude of this engine; but let me remark of the figures obtained in the test, that although very fair they are not extraordinary, and are discounted by several considerations besides the important fact that the engine tested was a new one. Thus rotary engines in general have an advantage in efficiency due to higher speeds; and generally the heat, friction, and steam losses may be slightly less on account of their greater compactness or weight efficiency, their lighter mechanism, easier steam distribution, and lesser clearance. Data of other engines indicate this; but these apparent virtues are mostly gained at a heavy expense of durability, which after all is the crucial test that prime movers have to pass. Will their spick and span efficiency endure under the tender care of the ordinary engine driver? Too often in the case of rotary engines the result has answered no; and I doubt greatly that the Brown engine will prove an exception.

I forbear commenting at length upon the irreversability of this engine, or upon the superfluous exhaust valves and the very questionable use of gear wheels and rotary steam valves in a high-speed motor; as these are merely details emphasising the general faultiness of design, what I want particularly to enforce is the absolute impracticability of any pressure engine containing higher paired packing surfaces, showing either a good average efficiency or an average life.

I have argued this matter with emphasis, not in jealousy of the inventor, or antagonism to any of the parties concerned, but because I fear the seeming laudation that has been widely bestowed on this engine may do real harm to the truer interests of mechanical science and progress by encouraging inventors in their too ready notion that any mechanism will suit a purpose, whether of rotary engines or anything else whatever, so long as it is a mechanism. For these there appears to be no *science* of mechanism, no fixed mechanical laws; and their innocent, yet energetic, anarchism is responsible for much confusion of ideas, even upon issues which really are clear as day.—I am, &c., J. Whitcher.

16, Brighton-road, Stoke Newington, N.
October 26th, 1891.

MR. EDISON AND ELECTRIC TRACTION.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I observe that, in a recent issue of the *Standard*, Messrs. Merryweather and Sons, on behalf of Mr. John Gordon, are contesting the originality of Mr. Edison's reported invention of a new method of electric traction, in which the current is conveyed to the motor through an insulated rail, divided into sections, of which only one or two sections are in circuit at a time; the said sections being put in and out of circuit by automatic switches placed at intervals along the line.

In a letter of mine which you kindly inserted in your issue of June 30, 1883—eight years ago—an exactly similar system is described and roughly illustrated. I published the invention in the hope that someone possessing greater facilities for its development might profit by the suggestion, and am glad to learn that Mr. Gordon has put it to a successful test. I trust the results will prove so profitable that he may, without compunction, accord the comparatively barren honour of priority to another British inventor.—I am, &c.,

John Tourtel.

Mansion House-chambers, 11, Queen Victoria-street, E.C.,
October 27, 1891.

[We have taken no notice of Mr. Edison's invention, except by the publication of the brief accounts given in the American Notes of our New York correspondent, because, so far, there does not seem to be anything original in it. Mr. Tourtel suggested the use of sectional conductors in the letter to which he refers; but the patent of Profs. Ayrton and Perry, No. 2,895 of May 11th in the same year, had already covered the ground very fully.—Ed. *E.*]

THE DETERMINATION OF CURRENTS IN ABSOLUTE ELECTRO-MAGNETIC MEASURE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir,—In § 19 of Mr. Searle's interesting Papers on the "Determination of Currents &c.," it is stated that "the strength of a magnetic shell is the magnetic moment of a square cm. of the shell." In common perhaps with others of your readers I shall be thankful to Mr. Searle if he will explain how the magnetic moment of a square cm. is obtained, since in this case the length $2l$ is indefinitely small, and at first sight one cannot see how the reasoning of § 18 applies; in fact, Mr. Searle has apparently omitted a connecting link which is absolutely necessary for the proper understanding of all that has since followed.—I am, &c.,

Oct. 23, 1891. "ia"

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I think that I can meet the difficulty felt by "ia" in the following way:—Consider a "magnetic shell," not indefinitely thin, but 1mm. in thickness. Draw upon its surface a set of lines, dividing it into small squares, each 1/10th mm. on a side. Suppose the "shell" divided into small prisms by planes passing through this network of lines at right angles to the surface. The "shell" will be divided into a large number of small magnets, whose length is 10 times their thickness. Apparently "ia" will find no difficulty in applying the reasoning of § 18 to each of these. Now, each of these small magnets has a definite magnetic moment, and the "magnetic moment of a square cm. of the shell," or its "strength," is 10,000 times the magnetic moment of each small magnet. However thin we suppose the shell to become, we can still suppose it divided into small magnets whose lengths are great compared with their diameters. Of course when the shell is very thin the strength of the poles of the small magnets must be very great, so as to keep the sum of the magnetic moments of all the small magnets, which can be packed together into a square cm. of the shell, a constant quantity i.—I am, &c., G. F. C. Searle.

Cambridge, Oct. 27, 1891.

THE INTERNATIONAL OKONITE COMPANY.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Our attention has been called to your report of the meeting of the International Okonite Company, and to Mr. Shaw's correction of the same. As the statement which appeared in your columns, although subsequently corrected,

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might convey the impression that there had been a general falling-off in the volume of electrical business during the period under review, it may be of interest for us to state that during this time the business of our electrical department had more than doubled in comparison with the previous twelve months,—an experience which we believe has been shared by many firms engaged in constructing electrical plant.—We are, &c., MATHER AND PLATT.

Salford Iron Works, Manchester,
October 27, 1891.

THE BREWERS' EXHIBITION AT THE AGRICULTURAL HALL.

During this week this Exhibition has been opened, and for the first time for some years we are able to note that a considerable amount of electric lighting is to be seen at quite a number of the exhibits. Further, we are glad to learn that the Directors of the Agricultural Hall Company have under their consideration the question of making a large permanent installation of the electric light for the general lighting of the Hall. Some years ago we believe the Directors accepted an offer from an electric lighting firm (now defunct) to light the hall; but from various causes the installation was a failure, and since then the Agricultural Hall Company have looked with scant favour upon the various proposals made to them for lighting the hall by electricity. Should the Directors decide to instal the electric light the order will amount to some thousands of pounds.

At the Exhibition under review, which will be closed to-morrow (Saturday), Messrs. Easton and Anderson have a large exhibit, showing their "Whitehall" dynamos at work. Amongst the exhibits being driven by this firm's machines are those of the Blackman Ventilating Company, Mr. Robert Boby, and Messrs. Crees and Company.

At the stall of the Trent Gas Engine Company there is on view a complete installation of the electric light, including a Trent gas engine coupled to one of Messrs. Laurence, Scott and Company's small motors, driving 20 16 c.p. lamps, which the Trent Gas Engine Company are guaranteeing do not cost more than 2d. per hour for gas; the installation is a very neat one, and is the only installation shown at a fixed price complete at the Exhibition. The Trent Company also show their patent "Trent" anti-fluctuators for preventing the jumping of the light when the pipes are also supplying a gas engine.

Mr. E. S. Hindley shows a number of his small portable engines; the Blackman Ventilating Company show an "Electric Blackman," being a Blackman fan and electric motor combined, similar to those employed by the committee of the recent Electrical Exhibition at Frankfort. As mentioned above, one of the 36in. Blackman fans is coupled direct to a "Whitehall" motor supplied by Messrs. Easton and Anderson; Messrs. H. Greene and Sons exhibit a number of fittings for the electric light; Mr. J. J. Hicks and Mr. Joseph Long have on view a large number of their well-known scientific instruments; and the Loft's Patent Check Till Company show what they describe as "an auto-telegraphic machine, a new invention of great interest, especially to scientific men."

Altogether, the thirteenth Annual Brewers' Exhibition is a very good show, and the managers (Messrs. Dale and Reynolds) are to be congratulated upon its success.

TRADE NOTES AND NOTICES.

ELECTRIC LIGHTING COMPANY, LIMITED (IN LIQUIDATION).—A meeting of this Company will be held at Mr. R. A. McLean's office, 1, Queen Victoria-street, E.C., on Nov. 26th, at 11, to receive the liquidator's report.

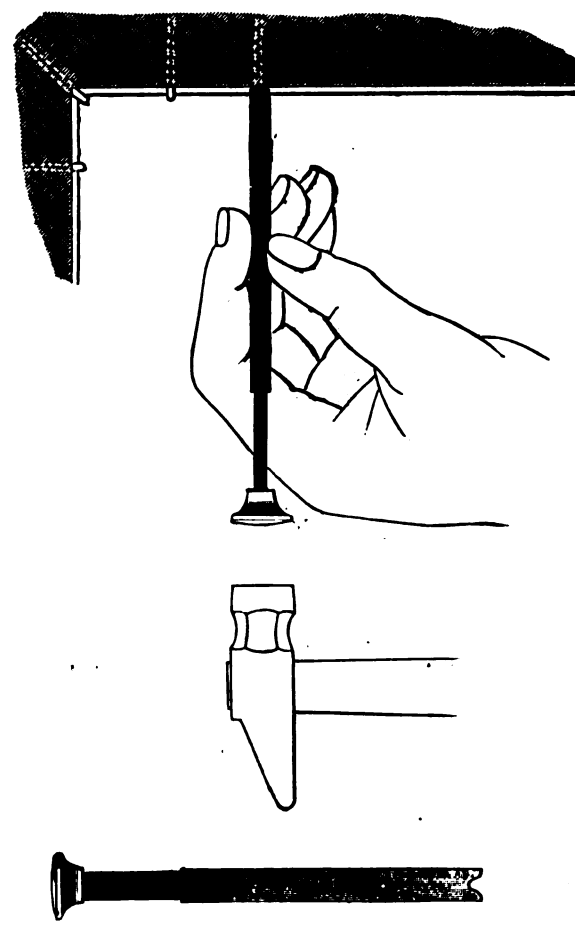
INTERNATIONAL ELECTRIC COMPANY.—We have to acknowledge the receipt of a well-printed and exhaustive catalogue of the above Company, which has just been issued. It is full of illustrations, setting out the various manufactures of the Company, including bells, relays, indicators and indicator movements, pushes, front and side door pulls (many of these are of very artistic design), switches, measuring instruments, portable batteries, insulators, wires and cables, telephones, microphones, and combination micro-telephones, as well as a great variety of other electrical accessories, including electro-medical apparatus. The list is a very complete one; but we would advise that the pink errata sheet, instead of being attached to the end of the book, should be placed in the front.

MESSRS. BENHAM AND FROUD (LIMITED).—This firm report that business is very brisk in their electrical fittings department, and that amongst the numerous orders recently received is one for an extremely recherché suite of ballroom brackets in heavy silver gilt, for one of the Indian princes. The design selected is of the choicest description. They further notify that a considerable trade is now springing up for their wrought-iron work fittings for the electric light.

MESSRS. JULIUS SAX.—This firm have fitted up 4,500 incandescent lamps, 1,500 electric bells, and 4,000 feet of speaking tube at the newly-erected Buckingham Palace-mansions, Buckingham Palace-road, S.W.

BANKRUPT.—Edwin Moorhouse, electrician, of 203, Hyde Park-road, and 40, New Briggate, Leeds, has been adjudicated a bankrupt.

A STAPLE DRIVER.—The well-known driver for paper fasteners has been adapted by Messrs. Woodhouse and Rawson for stapling electric bell and telephone wires. The arrangement should be very useful in running wires overhead and in difficult places. It appears that it is intended only for holding the staple in place until it has been driven far enough to hold, when the tube is removed,



Staple Driver.

and the staple is to be driven home. This is just what should not be done; and all the mischief arises from the use of staples because they are driven against the wire. If the driver were strong enough to take all the blows, and had an efficient stop, the hammer might be freely used, without any need of careful watching to see that the wire was not being cut.

REMOVAL NOTICE.—Mr. Sidney a'Court, A.M.I.C.E., A.M.I.E.E., Consulting Electrical Engineer, has removed from 6, Queen Anne's-gate, to 11, Little Queen-street, Westminster, S.W.

NEW FIRM.—Messrs. D. Young and J. T. Knowles inform us that they have commenced business as Patent Agents, under the style of D. Young and Co., at 11 and 12, Southampton-buildings, Chancery-lane, W.C.

WATERHOUSE ARC LIGHTING SYSTEM.—Messrs. Shippey Bros. notify that considerable improvements have been made in the Waterhouse arc lamp; and that this system, in combination with the Waterhouse dynamos for 3-brush regulation, will shortly be placed upon the European markets.

A PATENT ELECTRIC COMMUNICATOR FOR CARRIAGES, CABS, &c.—Messrs. Julius Sax are making a very useful communicator for vehicles, consisting of an indicator, which is placed on the splash-board in front of the driver, or let inside the roof of a hansom cab, and button-boards, which are fixed inside either cab or carriage for use of the occupant. The apparatus has been devised to enable the occupants of a vehicle to communicate their wishes to the driver. It is claimed that its action is certain and extremely simple. So

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soon as one of the buttons is touched the signal at once appears before the driver, a small bell ringing at the same time to call his attention. The order or signal remains on the indicator until cancelled by touching the button marked "clear." A bell and a patent dry battery is placed under the driver's seat. The accumulators used last for about 15 hours. Messrs. Julius Sax have already supplied these communicators to a number of well-known persons and firms, including the Prince of Wales, the Duke of Westminster, Messrs. de Rothschild, Col. North, and to the firms of carriage builders, Messrs. Slatter and Sons, Laurie and Marner, Shanks, McNaught and Co., Whitlock, Brainsby and Sons, Morel, and Mühlbacker; and they have also supplied communicators for the

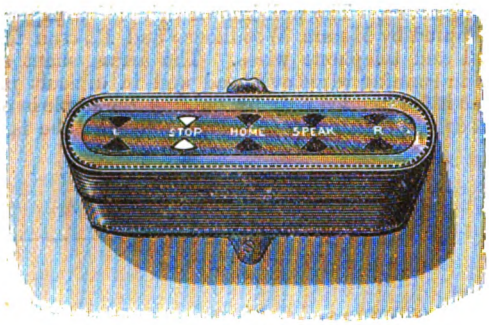

FIG. 1.

FIG. 2

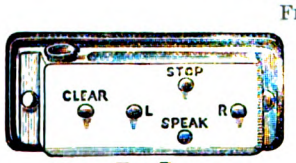

FIG. 3.

FIG. 4.

state coach of the Lord Mayor and Sheriff Harris's processional chariot. The illustrations (Fig. 1, 2, 3 and 4) given herewith are sufficiently explanatory of the apparatus.

COMPANIES' MEETINGS & REPORTS.

The Crompton Electric Supply Company of Australia (Limited).

The second annual ordinary general meeting of the shareholders of this Company was held at the registered offices of the Company, Mansion House-buildings, Queen Victoria-street, E.C., on Tuesday, the 27th inst.; J. F. Albright, Esq., in the chair.

We have been favoured with the following brief summary of the proceedings:—

The SECRETARY (Mr. F. R. Reeves) having read the notice convening the meeting,

The CHAIRMAN congratulated the shareholders upon the improved position of the Company, as shown by the accounts before the meeting, which accounts he regretted, however, the Directors were not able to ask the shareholders to pass as final, because of some small matters of detail required by the London auditors which had not yet been received from Sydney. He (the Chairman) had, however, no doubt as to the accuracy of the accounts, which were signed by the whole of the Sydney Directors, and certified by an independent firm of public accountants in Sydney. Adverting to the promotion by the Company of a Bill in the New South Wales Parliament for powers to supply electricity in the City of Sydney, the Chairman stated that the Bill had already passed the Committee. It was hoped that they would be able to carry the Bill through, as if this were accomplished the financial results to the Australian Company were expected to be very good indeed, to say nothing of the important additional influence which the carrying out of such a scheme would bring to the Company. He concluded by moving that the Directors' report and statement of accounts be received, and that the report of the Directors be adopted.

Mr. T. R. TUFNELL seconded the Chairman's resolution, but spoke at some length expressing his regret at the Sydney Committee not having supplied the whole of the information required by the London Board of Directors.

The resolution was put to the meeting and carried unanimously, as was also a resolution declaring additional dividends of 2 per cent. for 1890, making 8 per cent. in all for that year, and an interim dividend of 7 per cent. for 1891.

The retiring Director, Mr. W. G. Whiffen, was unanimously re-elected; and a resolution, voting 50 guineas per annum each to the Directors for their services, the maximum sum which the Directors would agree to accept, notwithstanding a proposal to vote a larger figure, was also passed.

The auditors, Messrs. Payne and Bankes, were re-elected; and the meeting closed with a vote of thanks to the Chairman and secretary.

The following is the report of the Directors referred to:—

The Directors having now received from Sydney the certified statements of account made up to May 31, 1891, two years from the date of commencement of the Company's business, have pleasure in submitting the same to the shareholders, together with a balance-sheet and profit and loss account, made up to the same date. The Directors, however, regret to state that the auditors report certain items in the Sydney accounts as being insufficiently detailed, and therefore they are unable to ask the shareholders to pass the accounts herewith as final.

Since the last meeting of the shareholders, Mr. J. F. Albright has visited Sydney and other parts of Australia, where he examined thoroughly into the business, and made an exhaustive and satisfactory report thereon, expressing himself hopeful as to future increase.

The Sydney Committee have, with the accounts, sent home a report, which is couched throughout in a sanguine and confident tone as to the position and prospects of the Company. Both of these reports can be seen upon application to the secretary.

A powerful syndicate has been formed in Sydney for the purpose of promoting a Bill in Parliament for the electric lighting of the city of Sydney. This Company hold shares in the syndicate, and by the latest advices there is considerable hope of the Bill being carried. Should the Bill pass this Company will materially benefit, both as engineers and contractors, besides adding greatly to its credit and influence.

Messrs. Crompton and Co. (Limited) have recently granted to this Company, without payment for goodwill, the exclusive right to carry out electric works in New Zealand under their patents. Business has already resulted therefrom, and the prospects of future work are good.

The net profits available for division, according to the accounts, after making full provision for bad and doubtful debts, and deducting the dividend paid in October last year, amount to £1,558. 3s. 6d. The Directors propose to distribute a further dividend of 2 per cent. for the year ending May 31, 1890, making, with the interim dividend already paid, a total of 8 per cent. for that year, and an interim dividend of 7 per cent. per annum for the second year to May 31st last, carrying the balance forward, pending the receipt of the details from Sydney required by the auditors.

In accordance with the Articles of Association, Mr. W. G. Whiffen retires from the Board by rotation, but being eligible, offers himself for re-election. The auditors, Messrs. Payne and Bankes, also offer themselves for re-election.

Messrs. Crompton and Company (Limited).

The following circular has been issued by the Directors of this Company, dated the 26th October inst.:—

"To the Shareholders,—The continued growth of this Company's business has forced upon the Directors the necessity of proposing some method of obtaining additional working capital, and the course which, after careful consideration, commends itself to the Board, is to ask the shareholders for power to increase the number of preference shares by the issue of 10,000 additional shares of £5 each. It is proposed that these shares shall rank in all respects *pari passu* with the existing preference shares, both as to cumulative dividend and distribution of assets, and that 5,000 shares shall be offered first to the present members of the Company at par. With regard to the second 5,000 shares, the Directors have it in contemplation to reserve these for a later issue, at a premium. The Directors request that the form of proxy enclosed with the circular may be signed and returned to the Company as an indication of the approval by the members of the course proposed."

Accompanying this circular is a formal notice of an extraordinary meeting to be held on Tuesday next, the 3rd prox., at the offices, Mansion House-buildings, E.C., at 3 o'clock, for the purpose of considering, and if approved, of passing the following resolution:—

"*That the capital of the Company be increased by the issue of 10,000 additional preference shares of £5 each, such shares to be numbered 20,001 to 30,000, inclusive, and to rank for preference or priority as regards dividends, and in the distribution of assets, and in all respects pari passu with the already existing preference shares of the Company, and the Directors are hereby authorised to issue these new shares at such times and on such terms as they may think fit.*"

Monte Video Telephone Company (Limited).

The following is the report of the Directors, to be presented to the shareholders at the annual general meeting to be held at the offices of the Company, No. 25, Abchurch lane, London, E.C., to-day (Friday), at 2.30 p.m.

Your Directors present herewith the audited statement of accounts for the year ending 31st July last, which, including the balance of £184 1s. 6d. brought forward from last year, shows a profit of £4,970 6s. 11d., after providing for all working expenses in Monte Video and London, and after writing off £114 14s. 8d. for proportion of preliminary expenses, and £20 for depreciation of furniture at head office and in Monte Video.

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Taking into consideration the present position of business in Monte Video, consequent upon the severe commercial and financial depression that has existed there since July, 1890, and having in view the difficulty of collecting the amounts due by subscribers, and also regarding the amount which has been expended on capital account through the necessity for new lines and connections, your Directors, being influenced by a desire to strengthen the position of the Company, feel that the only course open to them is to recommend that the sum of £4,500, as advised by the auditors, be added to the depreciation fund, and the balance of £470 6s. 11d. be carried forward to next year.

In view of the almost complete collapse of commerce in the River Plate during the year now completed, your Directors feel that there is cause for congratulation in the present position of the Company, the Manager of which has had several difficulties to contend with during the period now referred to. Through the stoppage of the National Bank at Monte Video, at a time when this Company held a large amount of its notes, a considerable loss was entailed. As might be expected, the loss in bad debts through failures consequent upon the position of business generally, has been considerable, and the sum of £1,512 8s. 7d. has been written off to meet this. A further loss was occasioned by the defalcation of one of the Company's collectors. Some unexpected expense has also been incurred by reason of new regulations issued by the Municipality of Monte Video enforcing the removal of supports and posts from the streets.

The number of subscribers has, naturally, fallen off to some extent, but there are still about 1,400 paying subscribers on the list, which is a position the Directors have every confidence in maintaining, and eventually strengthening on any improvement in the general condition of affairs at Monte Video.

Arrangements for the reduction of the expenses, both in Monte Video and in London, have been made.

As provided for by the Articles of Association, Mr. Holland retires from the Board, but, being eligible, offers himself for re-election. The Auditors, Messrs. Gérard van de Linde and Son, also retire, but offer themselves for re-election.

NEW COMPANIES, STATUTORY RETURNS, &c.

ECONOMIC BRICK COMPANY (LIMITED).—This Company was registered on October 20, 1891, with a capital of £20,000, in £1 shares. Among the objects is included that of producing and using electricity, magnetism, or other power.

WILLIAM MELBURN AND SONS (LIMITED).—Registered by Jordan and Sons, 120, Chancery-lane, W.C., with a capital of £20,000, in £5 shares. Objects: To acquire the engineering works known as the Britannia Iron-works, Stalybridge, and generally to carry on business as iron, steel and brass founders and engineers.

WADDINGTON, RATH, AND COMPANY (LIMITED).—This Company was registered on October 20, 1891, with a capital of £25,000, in £5 shares, by Messrs. Rooke and Sons, 45, Lincoln's Inn-fields, W.C. The objects are to acquire, and take over as a going concern, the business of india-rubber manufacturers, waterproof manufacturers, mechanical and electrical engineers, tube makers, &c., carried on by Messrs. H. H. Waddington and A. J. Rath, under the name of "Waddington, Rath, and Co." at Spring Bank Mills, Spring Bank-street, Hyde, Cheshire.

CITY OF LONDON ELECTRIC LIGHTING (PIONEER) COMPANY (LIMITED).—In our last issue we gave particulars of the voluntary winding-up of this Company, and the resolutions passed at the confirmatory meeting have been duly filed. The Company, as our readers are aware, was registered on February 5th last, with a capital of £100,000 in £50 shares, to amalgamate the three contracts of the Brush Electrical Engineering Company, Limited (West and Central), and the Laing, Wharton, and Down Construction Syndicate, Limited (East), preparatory to the formation of the larger company, the City of London Electric Lighting Company (Limited). At the time of the statutory return 1,000 shares had been taken up, and £25 had been called and paid on each of these shares.

ELECTRIC ARMS AND AMMUNITION SYNDICATE (LIMITED).—The annual return of this Company, made up to October 23, 1891, was filed on the following day. The Company was registered on October 9, 1889, with a capital of £40,000 in £100 shares. 290 shares have been taken up, upon 80 of which £70 per share has been called. 210 shares have been considered as fully paid. The calls paid amount to £4,860, leaving £740 unpaid. The principal holders are the American Arms and Ammunition Company, of 42, Broadway, New York (with 160 shares), and George B. Satterlee, of the same address (with 56 shares). Office: 35, Queen Victoria-street, E.C.

ELECTRIC TRACTION COMPANY (LIMITED).—The following was filed on Oct. 24, 1891:—"To the Registrar of Joint Stock Companies. I beg to inform you that a meeting of the above-named Company was duly held on September 30, 1891, for the purpose of having an account laid before them, showing the manner in which the winding-up of the Company had been conducted, and the property of the Company disposed of; and the same was done accordingly. Dated, London, Oct. 24, 1891. Fred. M. H. Jones, liquidator." This Company was registered on February 6, 1888, with a capital of £30,000 in £10 shares. At the time of the last return 1,000 fully paid, and 832 other shares were taken up, the principal holders being Lord Egerton of Tatton, Sir Robert Abercrombie, and F. W. J. Hubel. At a meeting held at New Broad-street House on July 1, 1891, a resolution for the winding up of the Company was passed, and subsequently confirmed; and the liquidator (Mr. G. A. Redford) was authorised to carry out the sale of the Company's property in cash or shares in the General Electric Power and Traction Company (Limited), agreed to by a contract, dated May 23, 1890, and made between this Company of the first part, Moritz Immisch and Co. of the second part, and the General Electric Power and Traction Company (Limited) of the third part. Offices: New Broad-street House, 35, New Broad-street, E.C.

ELECTRIC WELDING COMPANY (LIMITED).—An agreement made October 14, 1891 (and filed on the 21st) between the above Company (called the English Company) of the first part, the City of London Contract Corporation, Limited (called the Contract Corporation), of the second part, and the Thomson European Electric Welding Company, a Corporation established under the laws of the State of Maine in the U.S.A., and located at Portland in the said State (called the Thomson European Company) of the third part, states that whereas by an agreement dated August 20, 1891, between the Contract Corporation of the one part and the English Company of the other part, the Contract Corporation agreed to sell to the English Company, among other things, certain letters patent and patent rights, agreed to purchase by the Contract Corporation from the Thomson European Company in consideration of (among other things) the allotment to the Contract Corporation or their nominees of 8,333 ordinary fully paid £10 shares of the English Company and numbered 1,001 to 9,333 inclusive. The direction of the Contract Corporation nominate the Thomson European Company as the allottees of the said 8,333 fully paid £10 shares, and that as soon as the agreement had been filed with the Registrar of Joint-Stock Companies, the English Company will allot and issue to the Thomson European Company the said shares. Office: 2, Tokenhouse-buildings, E.C.

LAWS' ELECTRICAL APPLIANCES COMPANY (LIMITED).—An agreement made on October 16, 1891 (and filed on the 20th), between Major E. F. Law, of the first part, Messrs. C. T. D. Crews, Sinclair Macleay, J. T. F Otway, W. H. James, and E. F. Law of the second part, and the above-named Company of the third part, states that certain patents, No. 16,485, of 1886, granted to E. F. Law (for "improved means for facilitating the rapid publication of news"); 12,025, of 1887, granted to E. F. Law (for "improvements in apparatus for controlling typewriters, type-setting machines, and the like, by the aid of electricity"); 3,359, of 1888, granted to F. F. Law (for improvements similar to the above); 506, of 1889, granted to H. H. Lake as a communication from E. F. Law (for "improvements in and relating to electrical switches, chiefly designed for use in connection with apparatus for obtaining synchronous movements"; 185,824 (France), granted to E. F. Law; and 8,306, of 1890, granted to H. H. Lake, as a communication from E. F. Law, are to be sold to and purchased by the Company; and in full consideration thereof £3,600, in £5 shares, shall be allotted to Major Law and the parties of the second part. An agreement, dated October 17, 1891 (filed on the 20th), between William Clowes and Sons (Limited) and the above Company states that Messrs. Clowes are to erect a type-setting or composing machine, on which the patents of the Company can be advantageously worked, to allow one of their *employés* to superintend the direction thereof, and to assist in the proposed experiments for one month, to pay £100 to Laws' Company towards the costs of the said experiments, and to pay £25 to Laws' Company towards the preliminary expenses in the registration of the Company, and in full consideration thereof 66 fully-paid shares are to be allotted to William Clowes and Sons (Limited) or their nominees. The machine which is to be erected will remain the property of Messrs. Clowes, and Laws' Company are not authorised to construct machines of the kind of which Messrs. Clowes are the makers, or to allow the apparatus covered by Major Laws' invention to be used in combination with any other machine without the consent of Clowes and Sons. Our readers will doubtless remember that the above Company was registered on September 23, 1891, with a capital of £4,000, in £5 shares.

NORWICH ELECTRICITY COMPANY (LIMITED).—The first annual return of this Company, made up to the 10th October, 1891, was filed on the 22nd following. The Company was registered on the 25th January, 1890, and had a capital of £50,000 in £10 shares, 7 shares are taken up but nothing has been called thereon. The present shareholders are the original subscribers. Office: The Old Bank of England Chambers, Queen-street, Norwich.

CITY NOTES, &c.

BABCOCK AND WILLCOX (LIMITED).—The statutory meeting of the above Company was held on Tuesday, at the Cannon-street Hotel. The Chairman, Mr. Andrew Stewart, said that the allotment of the shares had been of a very satisfactory nature, and he hoped that a quotation of the shares would soon be obtained on the Stock Exchange. What the Directors had seen of the Company's business had exceeded their most sanguine expectations, and they were very full of work.

CITY AND SOUTH LONDON RAILWAY COMPANY.—The traffic receipts of this Company for the week ended October 25th amounted to £756; aggregate receipts for half-year to date, £11,961.

CONSOLIDATED TELEPHONE CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).—The Directors have declared the usual interim dividends for the half-year of £6 per cent. on the preferred and £5 per cent. on the ordinary shares, both less income-tax, and payable on and after November 16, 1891. The transfer books will be closed from the 23rd to 26th October.

ELECTRIC AND GENERAL INVESTMENT COMPANY (LIMITED).—It will be seen by our advertisement columns that the Directors have declared an interim dividend on the capital paid up on the ordinary shares at the rate of 20 per cent. per annum for the six months ended November 30, 1891, payable on and after that date.

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INDO-EUROPEAN TELEGRAPH COMPANY (LIMITED).—The Board of Directors of this Company have declared an interim dividend for the half-year ended June 30th last at the rate of 5 per cent. per annum, free of income-tax, payable on and after November 1st next.

JOHANNESBURG GAS COMPANY (LIMITED).—We understand that at the adjourned meeting of this Company, held on Wednesday, the resolutions were carried dissolving the Company and forming a new company under the title of the Johannesburg Lighting Company (see *The Electrician*, July 17th), and that the Transvaal Government has given the Company the monopoly of lighting Johannesburg by electricity or otherwise, giving further time in which to do the work on condition that 15 arc lights are installed immediately.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—For the half-year ended June 30th last, the Directors propose dividends of 6s. per share each on the first and second preference shares, with a distribution of 1s. per share on the Ordinary shares. The sum of £2,000 is to be placed to reserve, leaving £5,255 to be carried forward.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—After placing £25,000 to the reserve fund and £6,233. 10s. to the debenture redemption fund, the Directors recommend a dividend of 6s. per share, free of income-tax, or at the rate of £4 per cent. per annum, for the six months ended June 30th last, being the same as for the corresponding period. The traffic receipts of this Company for the week ended October 23rd, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brasilian Telegraph Company, were £3,708.

WESTMINSTER ELECTRIC SUPPLY CORPORATION (LIMITED).—The Stock Exchange have ordered the 17,047 additional shares (Nos. 42,954 to 60,000) to be quoted in the Official List.

COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Oct. 21.	Price Wednesday, Oct. 28.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Oct. 28. Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
£1,300,980	Stock	12/6	Anglo-American	48½ 49½	48 49	5 5 1	Jan., Apr., July, Oct.	49½	48¼
£2,849,510	Stock	25/0	Do. Preferred	87 88	87 88	5 16 6	" "	87¾	87⅝
£2,849,510	Stock	5/0	Do. Deferred	12⅜ 13½	12⅜ 13¼	..	" "	13	..
£250,000	100	4%	African Direct, Telegraph 4% Debentures	100 103	100 103	3 17 8	January and July ..	..	..
130,000	£10	5/0	Brazilian Submarine	12 12½	11½ 12	7 1 8	Mar., June, Oct., Dec.	12⅛	11⅝
£69,200	£100	5%	Do. 5 per Cent. Bonds	100 103	100 103	4 17 1	January and July ..	..	..
£75,000	£100	5%	Do. 5 per Cent. Bonds (2nd Series, 1906)	103 107	103 107	4 13 6	June and December	..	..
$7,716,000	$100	7%	Commercial Cable Capital Stock	125 130	140 142	4 18 7	April and October ..	139	131½
16,000	10	8/0	Cuba Submarine	10 11	10 11	7 5 6	February and August	10⅜	10½
6,000	10	10%	Do. Preference 10%	17 18	17 18	5 11 1	" "	..	..
12,931	5	2/0	Direct Spanish (£4 paid)	3½ 4	3½ 4	7 0 0	April and October..	3½	..
6,000	5	10%	Do. Preference 10%	9½ 10½	9½ 10½	4 15 3	" "	..	..
60,710	20	3/6	Direct United States	10⅞ 11⅛	10½ 11½	6 6 0	Jan., Apr., July, Oct.	11	10⅞
400,000	10	2/6	Eastern	14¼ 14½	14¼ 14½	4 9 8	" "	14 7/16	14 1/16
70,000	10	6%	Do. 6 per Cent. Preference	15 15½	15 15½	3 17 5	" "	15⅜	15⅜
£1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	108 111	108 111	3 12 1	May and November	..	..
£200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	107 110	4 10 11	February & August	107½	..
250,000	10	2/6	Eastern Extension	15⅛ 15⅜	15⅛ 15⅜	4 11 1	Jan., Apr., July, Oct.	15⅜	15⅛
£320,000	£100	4%	Do. 4 per Cent. Debenture Stock	106 109	106 109	3 13 5	February & August	108¼	..
£85,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	104 107	104 107	4 13 6	January and July ..	..	..
£135,000	100	5%	Eastern & S. African 5 per Cent. Mor Deb. 1900	102 105	102 105	4 15 3	" "	..	..
£201,600	100	4%	Do. 4% Mortgage Debentures 1909 (regd.)	99 102	99 102	3 18 5	January and August	100½	..
180,227	10	2 0	Globe Telegraph and Trust	9⅝ 9⅞	9¾ 10	5 7 6	Jan., Apr., July, Oct.	9⅞	9⅝
180,042	10	6%	Do. 6 per Cent. Preference	14¾ 15	14¾ 15	4 0 0	" "	15⅛	14⅞
150,000	10	5/0	Great Northern	18¾ 19½	18¾ 19½	4 8 4	Jan., April, and July	19	18⅝
£220,000	100	5%	Do. 5 per Cent. Debentures, 1883	105 108	105 108	4 12 7	March & September	..	..
17,000	25	37/6	Indo-European	41 43	42 44	5 13 8	May and November	..	..
38,348	10	5/0	London Platino-Brazilian	6½ 7½	6½ 7½	6 0 0	" "	..	..
£100,000	100	6%	Do. 6 per Cent. Debentures	105 108	105 108	5 11 1	March & September	..	..
9,000	8	4/0	Reuter's	8 8½	8 8½	4 14 1	April and October..	..	..
3,381	£100 Cert.	£2	Submarine Cables Trust 6% .....April coupon, £2	117 122	118 123	4 17 7	" "	..	..
15,609	10	6/0	West African Telegraph	7½ 8½	7½ 8½	5 17 8	January and July ..	..	..
£281,400	100	5%	Do. 5 per Cent. Debentures	98 101	98 101	4 19 0	March & September	..	..
30,000	10	2/0	West Coast of America	3½ 4	3½ 4	..	January and July ..	..	..
£150,000	100	8%	Do. Debentures 8% 1902	98 103	98 103	7 15 4	June and December	..	..
88,321	10	9d.	West India and Panama	1 1½	1⅜ 2	..	..	2	1⅝
34,563	10	6%	Do. 6 per Cent. 1st Preference	8½ 9	8¾ 9¼	6 9 9	May and November	9⅛	9
4,669	10	6%	Do. 6 per Cent. 2nd Pref.	7 8	7⅛ 8⅛	7 1 2	" "	..	..
61,683	15	9/0	Western and Brazilian	10⅜ 11¼	10⅜ 11¼	6 13 4	" "	11⅛	11
30,364	7½	1/6	Do 5 per Cent. Cumulative Preferred	6⅞ 7	6⅞ 7	5 7 3	—	7 1/16	..
30,364	7½	7/6	Do. 5 per Cent. Deferred	4¼ 4¾	4¼ 4¾	..	..	4⅜	4⅛
£189,700	100	6%	Do. 6 per Cent. Debs., Series "A" 1910	103 106	103 106	5 13 2	February & August	..	..
£237,200	100	6%	Do. 6 per Cent. Mort. Debs., Series "B" 1910	103 106	103 106	5 13 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	120 125	120 125	5 12 0	May and November	..	..
£173,100	£100	6%	Do, 6 per Cent. Sterling Bonds	98 102	98 102	5 17 8	March & September	..	..
			TELEPHONES.						
224,850	14/0	0/5½d	Consolidated Telephone Const. & Maintenance...	1 1/16 1 1/16	1 1/16 1 1/16	..	May and November	..	..
220,000	£1	4·76d.	Oriental (11s. paid)	1 1/16 1 1/16	1 1/16 1 1/16	6 3 11	Yearly	..	..
438,984	5	3/6	National	4⅜ 4⅝	4⅜ 4⅝	6 9 9	June and December	4⅝	..
15,000	10	6%	Do. 6 per Cent. Cumulative 1st Pref.	12½ 13	12½ 13	4 12 4	" "	13	..
15,000	10	6%	Do 6 per Cent. Cumulative 2nd Pref. (£8 pd)	12 13	12 13	3 14 1	" "	12 7/16	12
350,000	£100	4½%	Do. Deb. Stk. 4½% Prov. Cert. (fully pd)	105 107	106 108	4 3 4	..	107½	106½
58,000	5	1/0	United River Plate	2 3	1 2	..	January and July ..	1½	..
£146,370	Stock	5%	Do. 5 per Cent. Debenture Stock	85 95	85 95	5 5 8	—	..	..
			ELECTRICITY SUPPLY COMPANIES.						
1,000	£10	..	City of London Electric Lighting (£4 paid, £10 Sh.)	4⅛ 4¼ prem	⅛ ⅜	..	..	..	..
19,900	£5	..	Electricity Supply Co. of Spain	.. ..	.. ..	..	..	..	..
5,322	£5	..	House to House Electric	4½ 5	.. ..	..	..	..	..
30,000	£5	..	Liverpool Electric Supply (£3 paid)	3⅞ 4½	4⅜ 5⅛	..	..	..	..
111,000	5	..	London Electric Supply	1⅞ 2⅛	1⅞ 2⅛	..	..	..	..
43,900	£10	2/0	Metropolitan Electric Supply (fully paid)	9¾ 10¼	9⅞ 10⅛	..	..	10⅛	10
6,318	10	..	Notting Hill Electric Lighting (£8 paid)	5½ 6½	5⅝ 6⅝	—	..	6⅛	..
7,730	£5	3/6	St. James' and Pall Mall	8 8½	8 8½	—	..	8⅝	8 3/16
..	..	7%	Do. 7% Preference	7 7½	7⅛ 7⅜	..	..	7⅜	7 1/16
42,853	5	..	Westminster Electric Supply (£5 paid)	5⅞ 6	5⅝ 6⅛	..	..	6 1/16	6
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
£2,850	10	..	Blackpool Electric Tramway	.. ..	.. ..	..	..	..	..
77,978	3	1/8	Brush Electrical Engineering	3¼ 3⅜	3¼ 3⅜	5 2 9	..	3 7/16	3⅛
69,996	2	6%	Do. 6 per Cent. Preference	2 2¼	2 2¼	5 6 8	June and December	2 1/16	2
20,000	5	3/6	Crompton and Co., 7 per Cent. Pref. Shares	5 5½	5 5½	6 7 3	January and July ..	5⅜	..
17,139	5	..	Edison and Swan United	.. ..	.. ..	..	—	..	..
45,000	10	6%	Electric Construction	6¾ 7¼	6¾ 7¼	..	—	7⅛	6 13/16
70,000	2	10/0	Elmore's Patent Copper Depositing	3⅜ 3⅝	3⅜ 3⅝	..	—	3⅝	3 1/16
20,000	5	..	Fowler-Waring Cables (£4 paid)	2 3	2 3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	20 21	20 21	4 15 3	February & August	20½	20¼
£200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	March & September	..	..
11,334	£10	6/1	International Okonite Limited Ordinary	6 7	6 7	..	..	..	..
11,334	£10	8/0	Do. Preference	8½ 9½	8½ 9¼	8 13 0	..	..	..
£20,000	9	..	Manchester Edison-Swan "A" (£1 paid)	½ ⅝	½ ⅝	..	..	..	..
78,949	5	2/1½	Swan United (£3. 10s. paid)	5 5½	5 5½	6 7 5	May and November	5½	5
37,350	12	12/0	Telegraph Construction and Maintenance	42 44	42 44	5 9 3	March and July.....	44½	43½
50,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	102 105	102 105	4 15 3	January and July ..	..	..
..	£5	..	Woodhouse and Rawson Ordinary (£2. 10s. paid)	2⅛ 2⅝	.. ..	..	..	..	..
—	£5	..	Do. Preference (fully paid)	3¾ 4	.. ..	..	..	..	..
			RAILWAYS.						
50,000	£10	—	City and South London Railway		4	—	—	3¼	—

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